

# M21131/M21151

## 72x72/144x144 3.2 Gbps Asynchronous Crosspoint Switch with Amplif-EYE Signal Conditioning

The M21131/M21151 is a 3.2 Gbps, 72/144 lane high-speed, low-power CMOS asynchronous non-blocking crosspoint switch. It operates from DC to 3.2 Gbps making it suitable for many telecom, datacom, and broadcast video applications.

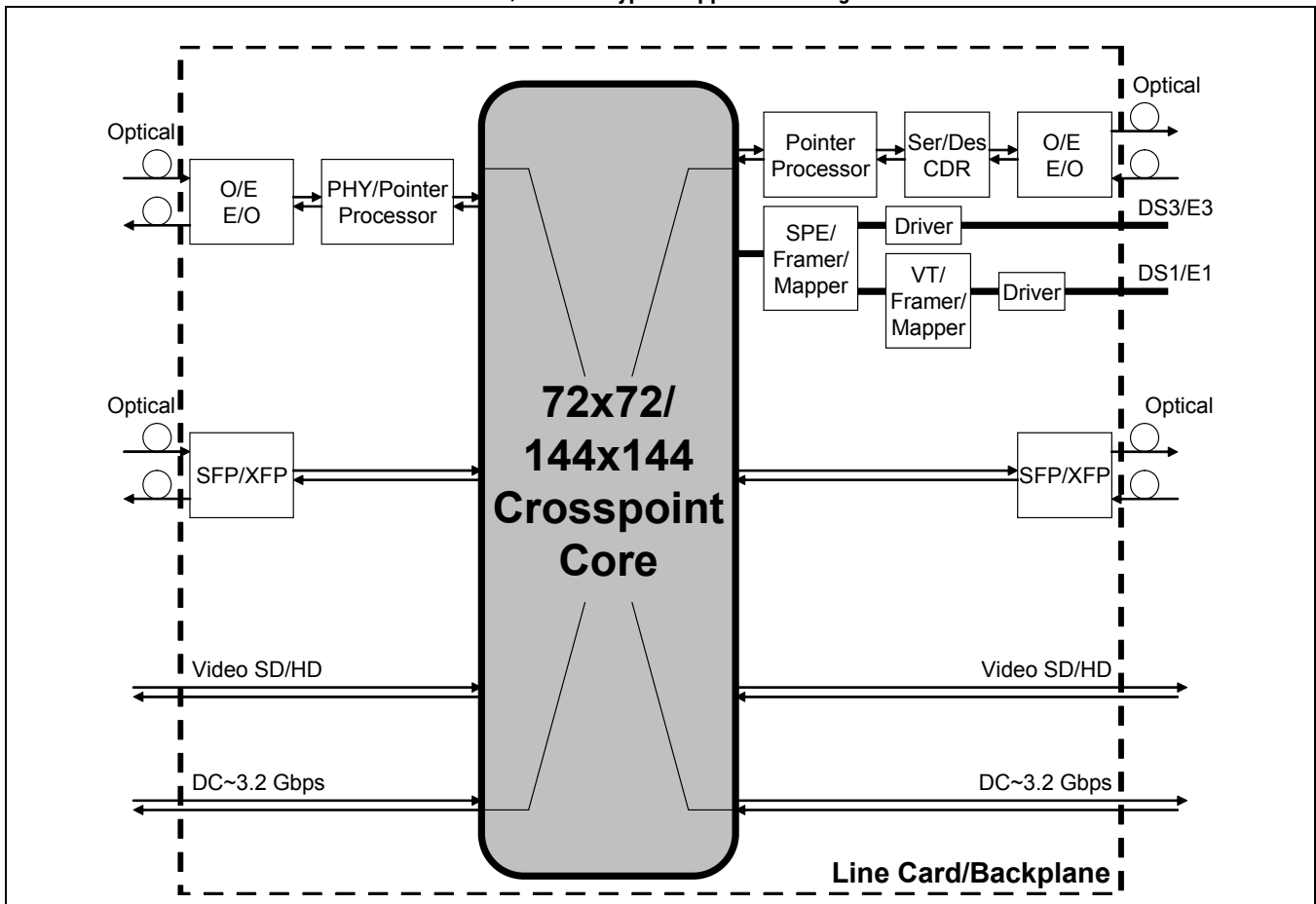
### Applications

- Large NxN cascaded switch fabrics up to 10 Terabits/sec (Tbps)
- Dense-Wavelength-Division Multiplexing (DWDM) telecom/datacom Switcher/Router
- Serial Digital Video Switcher/Router (3G/HD/SD-SDI)
- Storage Area Network (SAN) Switcher/Router
- High-speed Automated Test Equipment (ATE)
- Disaster recovery and redundancy systems

### Features

- 72/144 inputs by 72/144 outputs non-blocking crosspoint switch
- 3.2 Gbps Non-Return to Zero (NRZ) raw data bandwidth
- Global or individual lane programmable Input Equalization, output De-Emphasis, and drive levels
- Pinout and software compatible with the M21141/M21161
- Input signal activity monitor
- Flexible interface AVdd\_IO +1.2/1.5/1.8/2.5V
- Built-in Pseudo-Random Bit Sequence (PRBS) generator/checker
- SmartPower™ dynamically reduces power consumption
- Green/RoHS compliant package

M21131/M21151 Typical Application Diagram



## Ordering Information

### 72x72 3.2 Gbps Crosspoint Switch Ordering Information

Part Number	Package Type	Substrate Material	Green/Eutectic	Operating Temperature	Availability
M21131-12 <sup>(1)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Eutectic	0°C to 85 °C	Now
M21131G-12 <sup>(1)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Green	0°C to 85 °C	Now
M21131G-13 <sup>(1,2)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Green	0°C to 85 °C	Now
M21131-22	1156-terminal, 35 mm, BGA	CPCore	Eutectic	0°C to 85 °C	Production orders: 01/01/2011
M21131G-22	1156-terminal, 35 mm, BGA	CPCore	Green	0°C to 85 °C	Production orders: 01/01/2011
M21131G-23 <sup>(2)</sup>	1156-terminal, 35 mm, BGA	CPCore	Green	0°C to 85 °C	Production orders: 01/01/2011
(1) Not recommended for new designs					
(2) Improved input sensitivity especially for SDI applications					

### 144x144 3.2 Gbps Crosspoint Switch Ordering Information

Part Number	Package Type	Substrate Material	Green/Eutectic	Operating Temperature	Availability
M21151-13 <sup>(1)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Eutectic	0°C to 85 °C	Now
M21151G-13 <sup>(1)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Green	0°C to 85 °C	Now
M21151G-14 <sup>(1,2)</sup>	1156-terminal, 35 mm, BGA	Ceramic	Green	0°C to 85 °C	Now
M21151-23	1156-terminal, 35 mm, BGA	CPCore	Eutectic	0°C to 85 °C	Production orders: 01/01/2011
M21151G-23	1156-terminal, 35 mm, BGA	CPCore	Green	0°C to 85 °C	Production orders: 01/01/2011
M21151G-24 <sup>(2)</sup>	1156-terminal, 35 mm, BGA	CPCore	Green	0°C to 85 °C	Production orders: 01/01/2011
(1) Not recommended for new designs					
(2) Improved input sensitivity especially for SDI applications					

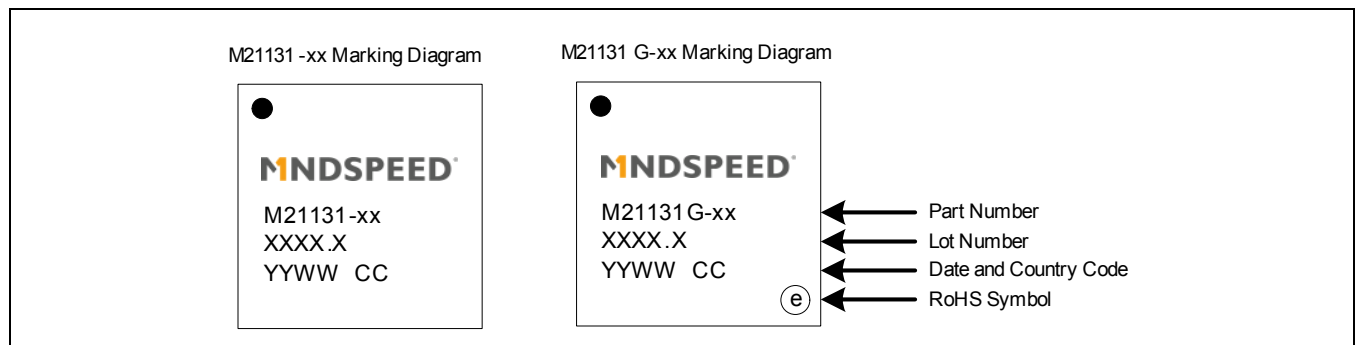
**NOTE:**

- Mindspeed is changing the package substrate material from Ceramic to CPCore. For traceability, the revision code will be changed from -1x to -2x to signify this change. The device silicon will remain unchanged during this transition. The differences between the CPCore and Ceramic packaged material are outlined in [Section 2.1.3](#).
- These devices are shipped in trays.
- The letter “G” designator after the part number indicates that the device is RoHS compliant. Refer to [www.mindspeed.com](http://www.mindspeed.com) for additional information. The RoHS compliant devices are backwards compatible with 225 °C reflow profiles.

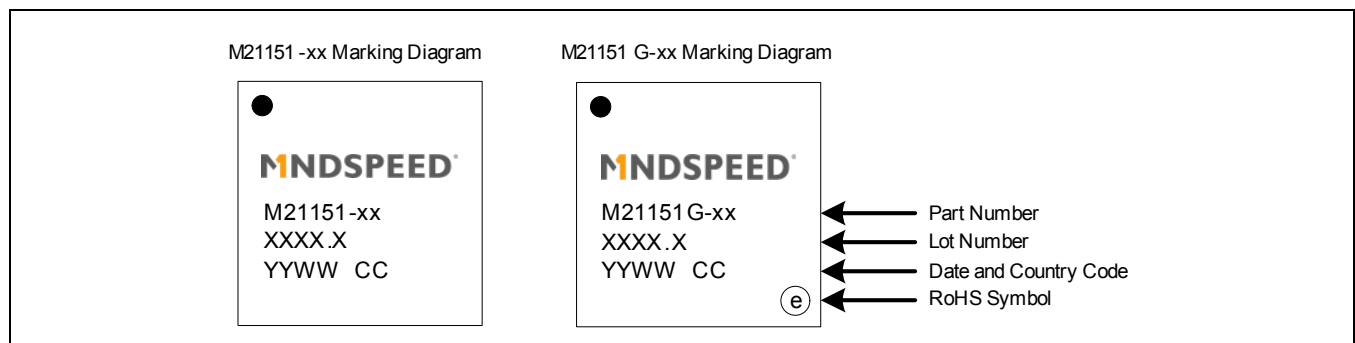
## Revision History

Revision	Level	Date	Description
I	Released	December 2012	Corrected an error in table 1-1. Maximum voltage on CMOS inputs should be referenced to DVDD_IO instead of AVDD_IO
H	Released	July 2010	Expanded ordering matrix to include all current revisions.
G	Released	May 2010	Revised part numbers to -23 and -24. Corrected signal names on pin AF1 INP[117] and AF2 INN[117]. Updated Marking Diagrams. Update package from ceramic to CPCore. Please see <a href="#">Section 2.1.3</a> for package changes
F	Released	October 2009	Revised for M21131-13 part details. Added marking diagrams. Removed M21131-12 parameters from <a href="#">Table 1-6</a> . Removed BGA Assignments by Ball Name Tables. Corrected global control of de-emphasis duration values in <a href="#">Table 3-33</a> .
E	Released	May 2009	See prior revisions for revision history details.
D	Released	September 2008	See prior revisions for revision history details.

## M21131 Marking Diagrams



## M21151 Marking Diagrams





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# 1.0 Electrical Characteristics

Unless noted otherwise, specifications in this section are valid with  $AV_{DD\_CORE} = 1.2V$ ,  $AV_{DD\_IO} = 1.8V$ , and  $DV_{DD\_IO} = 2.5V$  power supplies, 25 °C ambient temperature, 800 mVpp differential input/output data swing, PRBS 2<sup>15</sup>- 1 test pattern at 3.2 Gbps,  $R_L = 50\Omega$ .

**Table 1-1. Absolute Maximum Ratings <sup>(1)</sup>**

Symbol	Parameter	Minimum	Typical	Maximum	Unit
$DV_{DD\_IO}$	Digital logic I/O supply	0		+3.6	V
$AV_{DD\_IO}$	Switch I/O supply	0		+2.7	V
$AV_{DD\_CORE}$	Switch core supply	0		+1.5	V
$V_{CML}$	DC input voltage (CML)	$V_{SS} - 0.5$	—	$AV_{DD\_IO} + 0.5$	V
$V_{CMOS}$	DC input voltage (CMOS)	$V_{SS} - 0.5$	—	$DV_{DD\_IO} + 0.5$	V
Tst	Storage temperature	-65		+150	°C
VESD	Human body model (low-speed)	1000		—	V
VESD	Human body model (high-speed)	500		—	V
VESD	Charge device model	150		—	V

**NOTES:**

1. Exposure to these conditions over extended periods of time may affect device reliability.

**Table 1-2. Recommended Operating Conditions**

Symbol	Parameter	Notes	Minimum	Typical	Maximum	Unit
$DV_{DD\_IO}$	Digital supply voltage	2	+1.71	+1.8/2.5/3.3	+3.47	V
$AV_{DD\_IO}$	Analog I/O supply voltage	2	+1.14	+1.2/1.5/1.8/2.5	+2.63	V
$AV_{DD\_CORE}$	Switch core supply voltage	2	+1.14	+1.2	+1.26	V
Tc	Package heat spreader temperature	1, 3	0	—	+85	°C
$\theta_{JC}$	Junction to Case Thermal Resistance			0.3		C/W

**NOTES:**

1. Lower limit is ambient temperature and upper limit is case temperature.
2. Power supply tolerances are  $\pm 5\%$ .
3. Please refer to the 144 XPS thermal Application Note for thermal design and bolted down heat sink recommendations for this product. The use of adhesively mounted heatsinks is prohibited.

**Table 1-3. M21131 Power DC Electrical Specifications**

Symbol	Parameter	Notes	Minimum	Typical	Maximum <sup>(1)</sup>	Unit
AIDD_CORE	Core current consumption, small output swing, SmartPower on	1,2	—	4.2	4.4	A
	Core current consumption, small output swing, SmartPower off	1,2	—	8.6	9.0	A
AIDD_IO	I/O current consumption, small output swing, +1.2V I/O	2	—	1.3	1.4	A
	I/O current consumption, small output swing, +2.5V I/O	2	—	2.8	3.0	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	6.6	7.0	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	12.1	12.8	W
AIDD_CORE	Core current consumption, medium output swing, SmartPower on	1,2	—	4.4	4.6	A
	Core current consumption, medium output swing, SmartPower off	1,2	—	8.8	9.2	A
AIDD_IO	I/O current consumption, medium output swing, +1.2V I/O	2	—	2.0	2.1	A
	I/O current consumption, medium output swing, +2.5V I/O	2	—	3.1	3.2	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	7.7	8.0	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	12.9	13.5	W
AIDD_CORE	Core current consumption, high output swing, SmartPower on	1,2	—	4.5	4.7	A
	Core current consumption, high output swing, SmartPower off	1,2	—	8.9	9.4	A
AIDD_IO	I/O current consumption, high output swing, +1.2V I/O	2	—	2.5	2.7	A
	I/O current consumption, high output swing, +2.5V I/O	2	—	3.5	3.7	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	8.4	8.9	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	14.2	14.9	W
DIDD_IO	Digital current consumption DV <sub>DD-IO</sub> = +2.5V	2	—	0.626	25	mA
<b>NOTES:</b>						
1. Core power supply is +1.26V, (+1.20V, +5%).						
2. 1-to-1 mapping (Input0 to Output0, Input1 to Output1,...).						

**Table 1-4. M21151 Power DC Electrical Specifications (1)**

Symbol	Parameter	Notes	Minimum	Typical	Maximum	Unit
AIDD_CORE	Core current consumption, small output swing, SmartPower on	1,2	—	8.3	8.5	A
	Core current consumption, small output swing, SmartPower off	1,2	—	11.2	11.5	A
AIDD_IO	I/O current consumption, small output swing, +1.2V I/O	2	—	2.5	2.6	A
	I/O current consumption, small output swing, +2.5V I/O	2	—	3.6	3.7	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	12.9	13.3	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	18.9	19.5	W
AIDD_CORE	Core current consumption, medium output swing, SmartPower on	1,2	—	8.4	8.7	A
	Core current consumption, medium output swing, SmartPower off	1,2	—	11.3	11.7	A
AIDD_IO	I/O current consumption, medium output swing, +1.2V I/O	2	—	3.6	3.8	A
	I/O current consumption, medium output swing, +2.5V I/O	2	—	4.7	4.9	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	14.4	15.0	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	21.8	22.7	W
AIDD_CORE	Core current consumption, high output swing, SmartPower on	1,2	—	8.7	8.9	A
	Core current consumption, high output swing, SmartPower off	1,2	—	11.6	11.9	A
AIDD_IO	I/O current consumption, high output swing, +1.2V I/O	2	—	4.3	4.5	A
	I/O current consumption, high output swing, +2.5V I/O	2	—	5.5	6.1	A
Pdiss	Power dissipation at +1.2V CORE, +1.2V I/O, SmartPower on	2	—	15.5	16.1	W
	Power dissipation at +1.2V CORE, +2.5V I/O, SmartPower on	2	—	24.2	25.9	W
DIDD_IO	Digital current consumption $DV_{DD\_IO} = +2.5V$	2	—	0.626	25	mA
<b>NOTES:</b>						
1. Core power supply is +1.26V, (+1.20V +5%).						
2. 1-to-1 mapping (Input0 to Output0, Input1 to Output1,...).						

**Table 1-5. CMOS DC Electrical Specifications**

Symbol	Parameter	Minimum	Typical	Maximum	Unit
$V_{OH}$	Output logic high $I_{OH} = -100 \mu A$	$0.8 \times DV_{DD\_IO}$	—	—	V
$V_{OL}$	Output logic low $I_{OL} = 100 \mu A$	—	—	$0.2 \times DV_{DD\_IO}$	V
$V_{IH}$	Input logic high	$DV_{DD\_IO} - 0.3$	—	+3.6	V
$V_{IL}$	Input logic low	0	—	+0.3	V



**Table 1-6. PCML Input Electrical Specifications (1)**

Symbol	Parameter	Notes	Minimum	Typical	Maximum	Unit
V <sub>ID</sub>	Input differential voltage (peak-to-peak) PRBS SDI Pseudo-Pathological Pattern	1	100 —	— 350	1200 —	mV
V <sub>ICM</sub>	Input common-mode voltage		—	AV <sub>DD_IO</sub> - 300	—	mV
V <sub>IH</sub>	Maximum input high voltage		—	—	AV <sub>DD_IO</sub> + 300	mV
V <sub>IL</sub>	Minimum input low voltage		AV <sub>DD_IO</sub> - 800	—	—	mV
S <sub>11</sub>	Input return loss (40 MHz to 2 GHz)		—	-10.0	—	dB
S <sub>11</sub>	Input return loss (2 GHz to 5 GHz)		—	-5.0	—	dB

**NOTES:**

- Input sensitivity specified @ 3.2 Gbps PRBS 2<sup>23</sup>-1 and BER 10<sup>-12</sup>.

**Table 1-7. PCML Output Specifications**

Symbol	Parameter	Notes	Minimum	Typical	Maximum	Unit
DR <sub>OUT</sub>	Operating data rate (NRZ data)	—	DC	—	3.2	Gbps
J <sub>OUTRMS</sub>	Output data broadband jitter (RMS)	—	—	—	6.0	ps
J <sub>OUTP-P</sub>	Output data broadband jitter (peak-to-peak)	—	—	—	36.0	ps
T <sub>RISE/FALL</sub>	Rise time/fall time (20 to 80%)	2	—	—	145	ps
V <sub>OD</sub>	Low swing: differential swing Medium swing: differential swing High swing: differential swing	— — 3	390 700 920	650 950 1225	700 1200 1600	mV
S <sub>22</sub>	Output return loss (40 MHz to 2.5 GHz) Output return loss (2.5 GHz to 5 GHz)	1	— —	-15.0 -5.0	— —	dB
t <sub>DJ</sub>	Output Deterministic Jitter (ISI)		—	125	—	mUI
t <sub>RJ</sub>	Output Random Jitter		—	2	—	mUI RMS

**NOTES:**

- RF parameters measured into a 50Ω load on M21131/M21151 EVM.
- Rise/Fall time specification is for lowest output swing settings. Rise/Fall time improves with higher output swing settings.
- Package and recommended heat sink are not rated for this mode at AV<sub>DD\_IO</sub> = +2.5 V due to high power dissipation; improved thermal management at the board level would be necessary to use this mode at AV<sub>DD\_IO</sub> = +2.5 V.

Figure 1-1. Input Equalization Test Setup

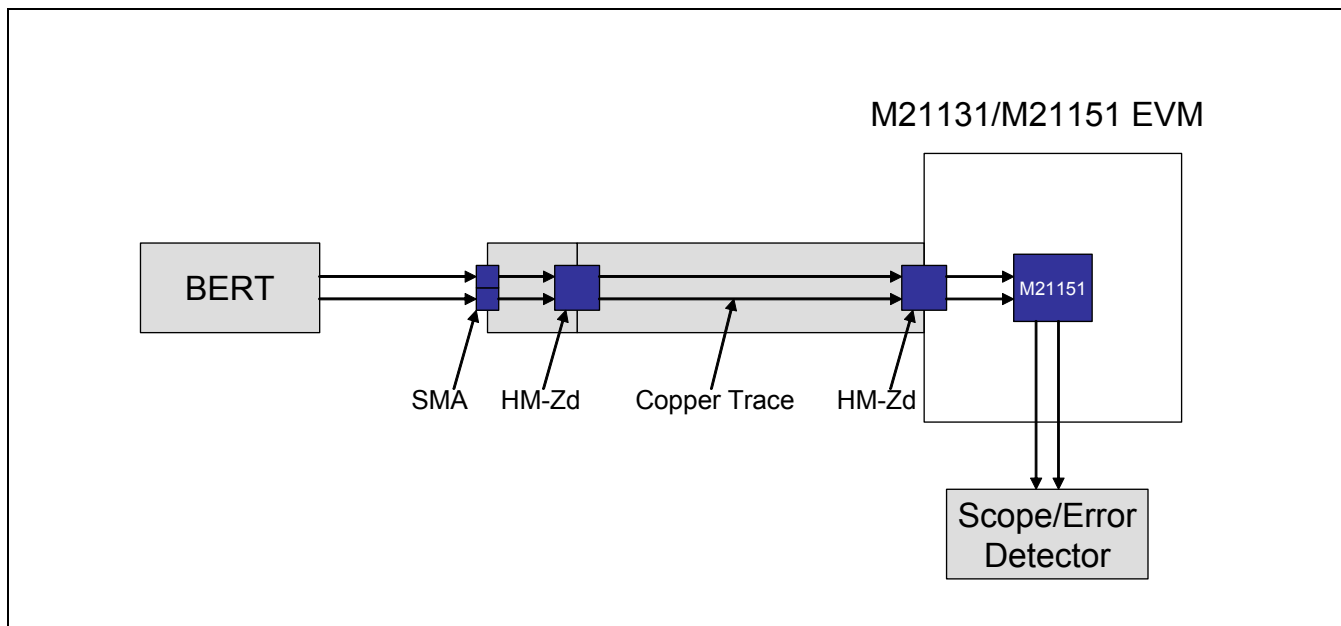
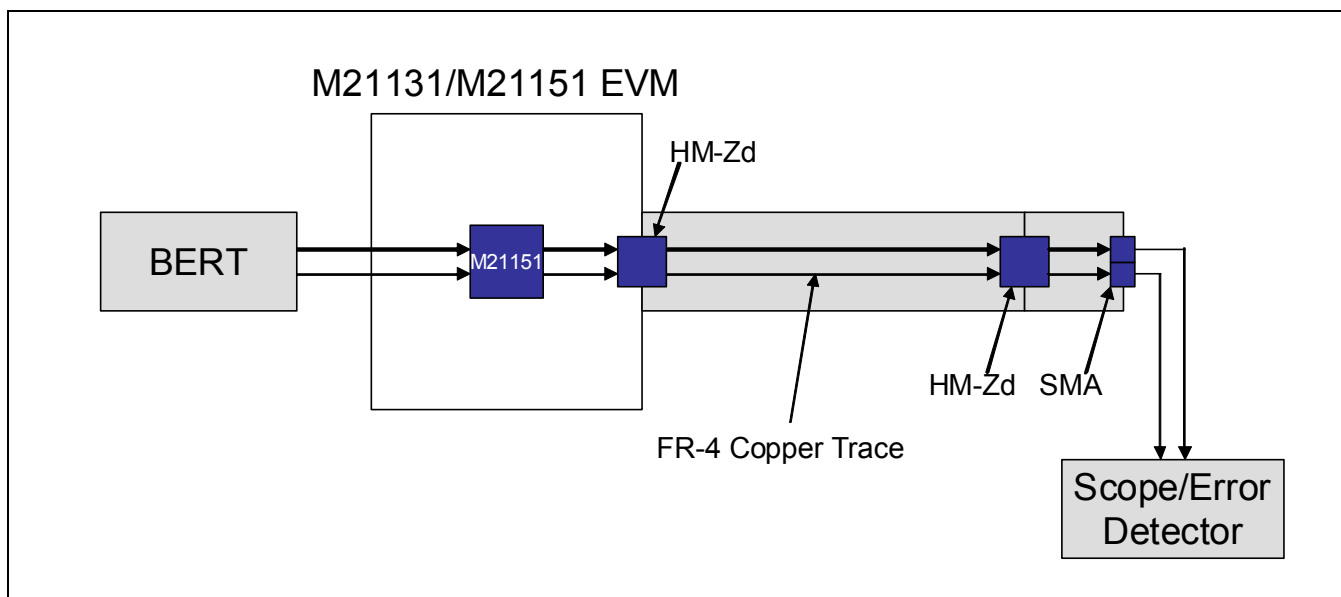


Figure 1-2. De-Emphasis Test Setup





## 2.0 Package Outline Drawing and Pin Descriptions

### 2.1 Package Outline Drawing

#### 2.1.1 M21131 and M21151 Packaging Drawing (-12/-13/-14)

Figure 2-1 illustrates the M21131/M21151 (-12/-13/-14) overall package dimensions and a cross sectional view, Figure 2-2 is a bottom view of the package with ball assignments. The substrate thickness is 2.03 millimeters. All dimensions are in millimeters. The ball count is 1156, the width of each ball is 0.60 millimeters, and the ball pitch from center to center is 1.00 millimeters.

Figure 2-1. M21131/M21151 (-12/-13/-14) Package Outline Top View and Cross Sectional View (in mm)

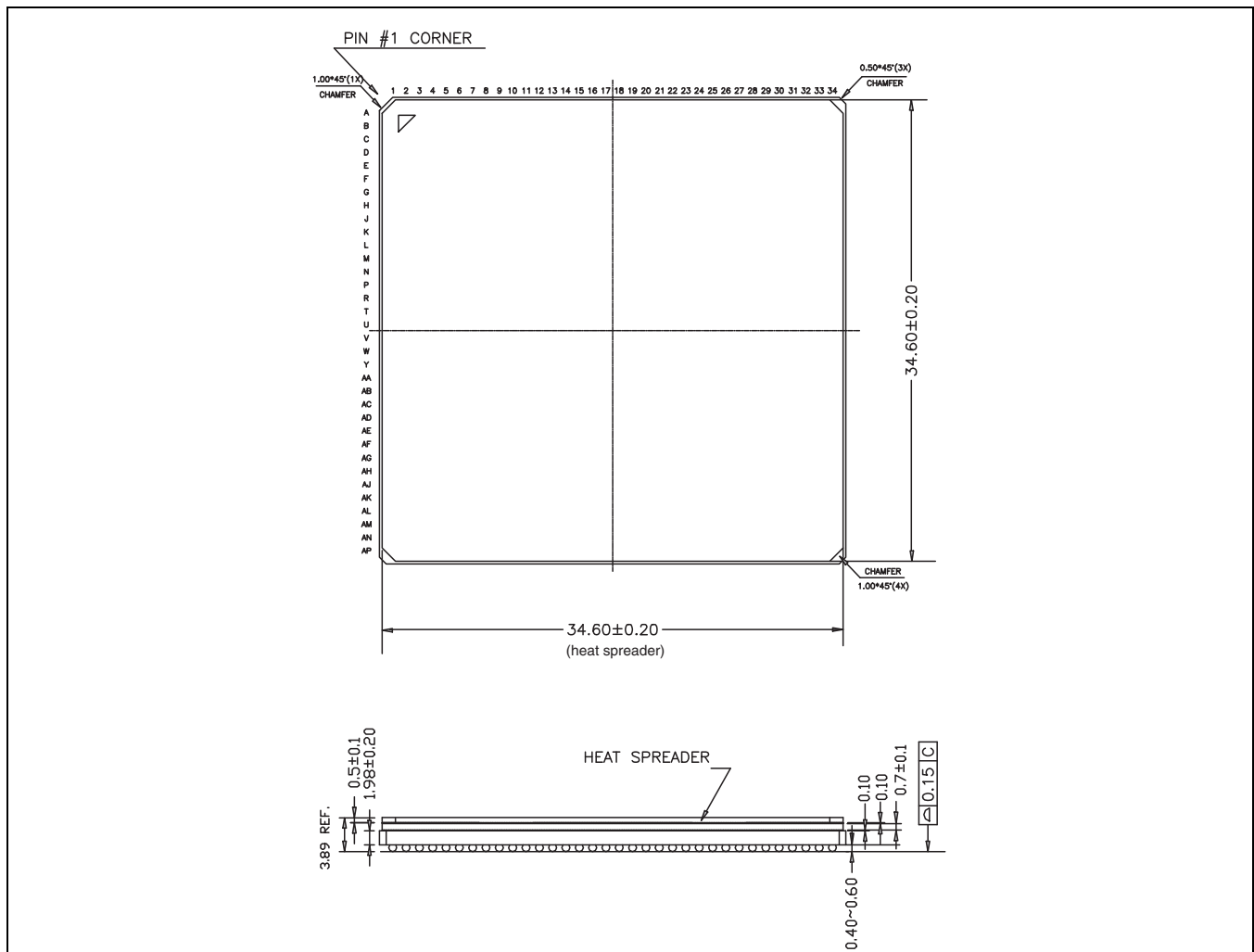
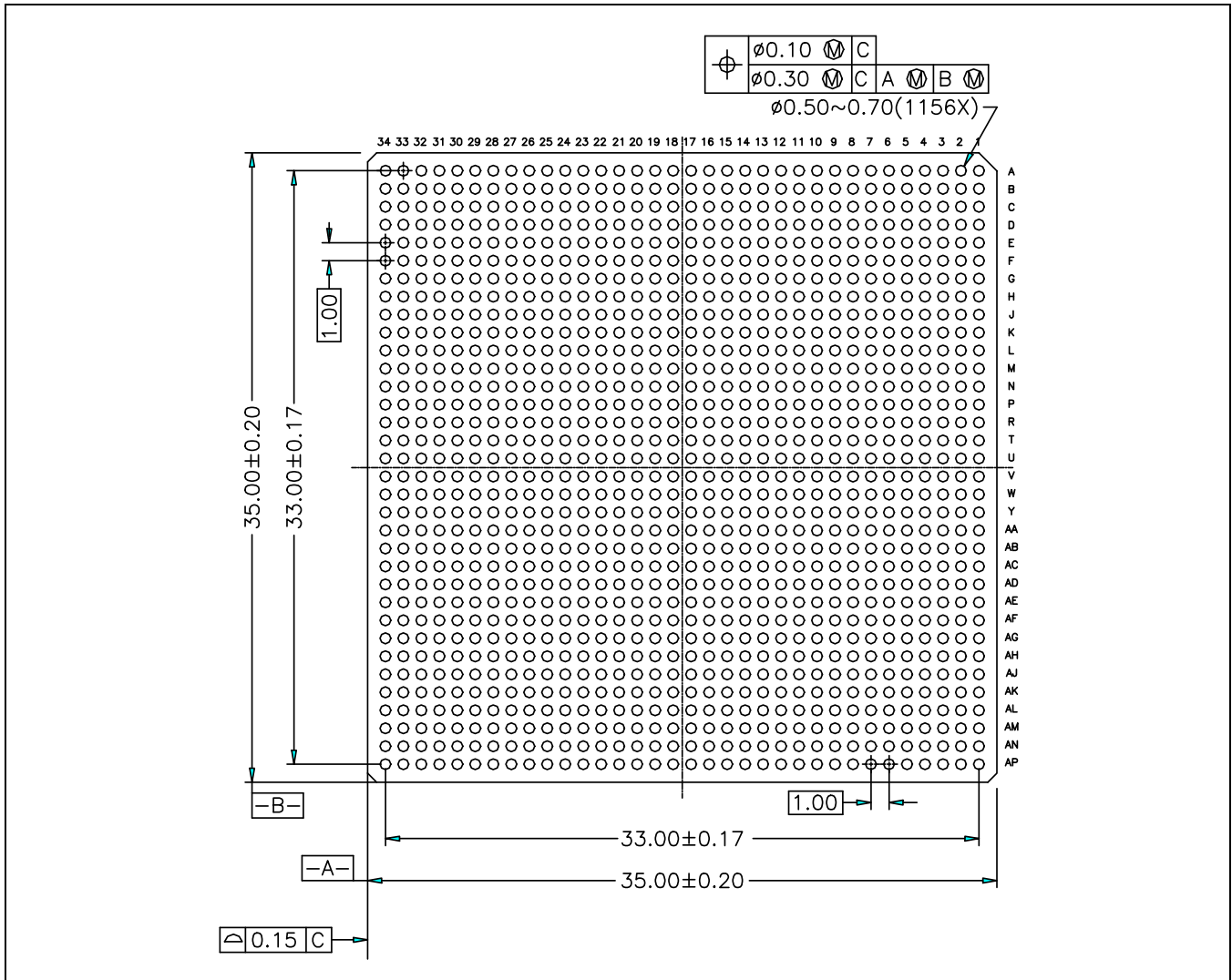


Figure 2-2. M21131/M21151 (-12-13/-14) Bottom View of Package (in mm)



### 2.1.2 M21131 and M21151 Packaging Drawing (-22/-23/-24)

Figure 2-3 illustrates the M21131/M21151 (-22/-23/-24) overall package dimensions and a cross sectional view, Figure 2-4 is a bottom view of the package with ball assignments. The substrate thickness is 2.03 millimeters. All dimensions are in millimeters. The ball count is 1156, the width of each ball is 0.60 millimeters, and the ball pitch from center to center is 1.00 millimeters.

Figure 2-3. M21131/M21151 (-22/-23/-24) Package Outline Top View and Cross Sectional View (in mm)

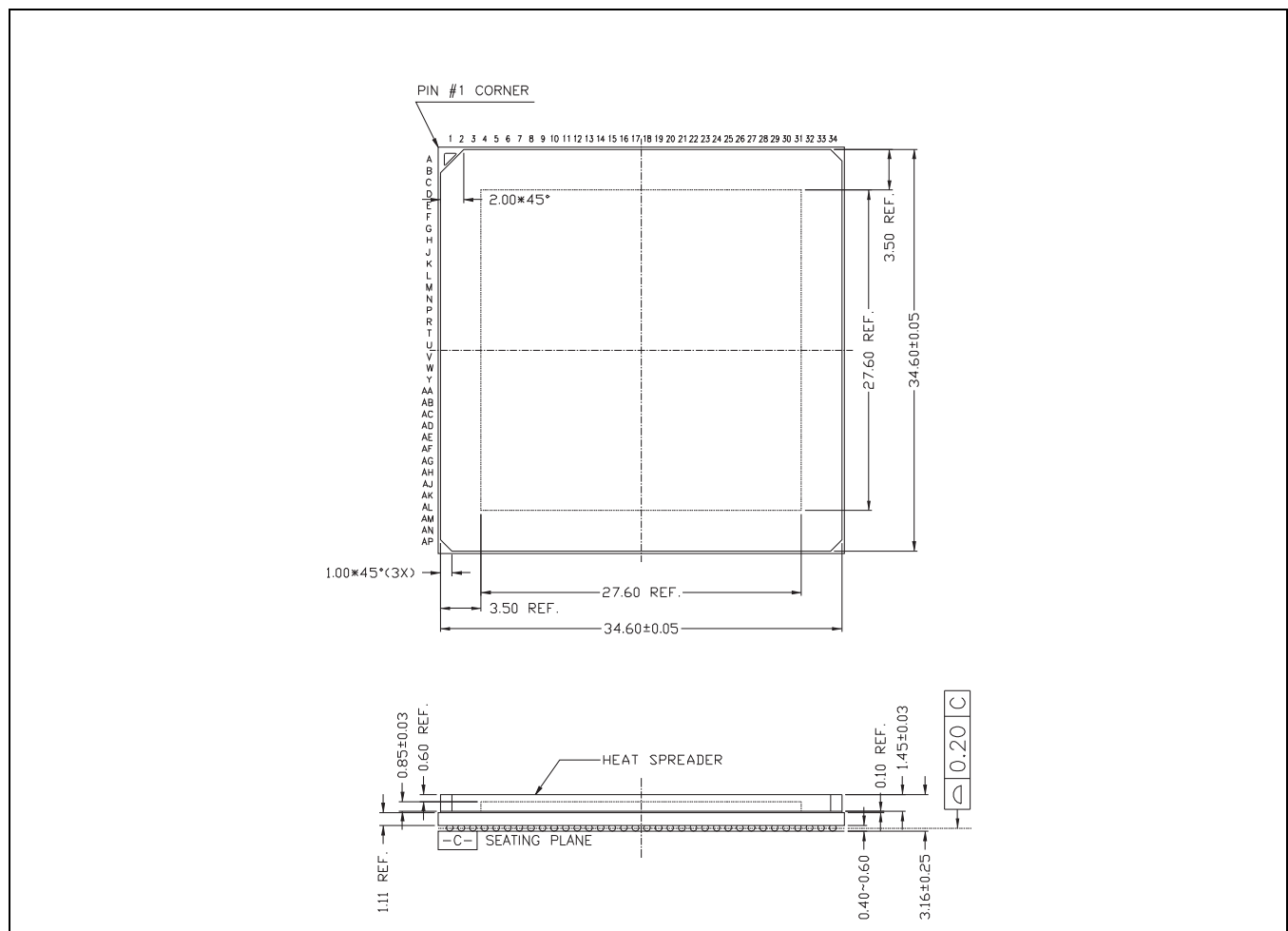
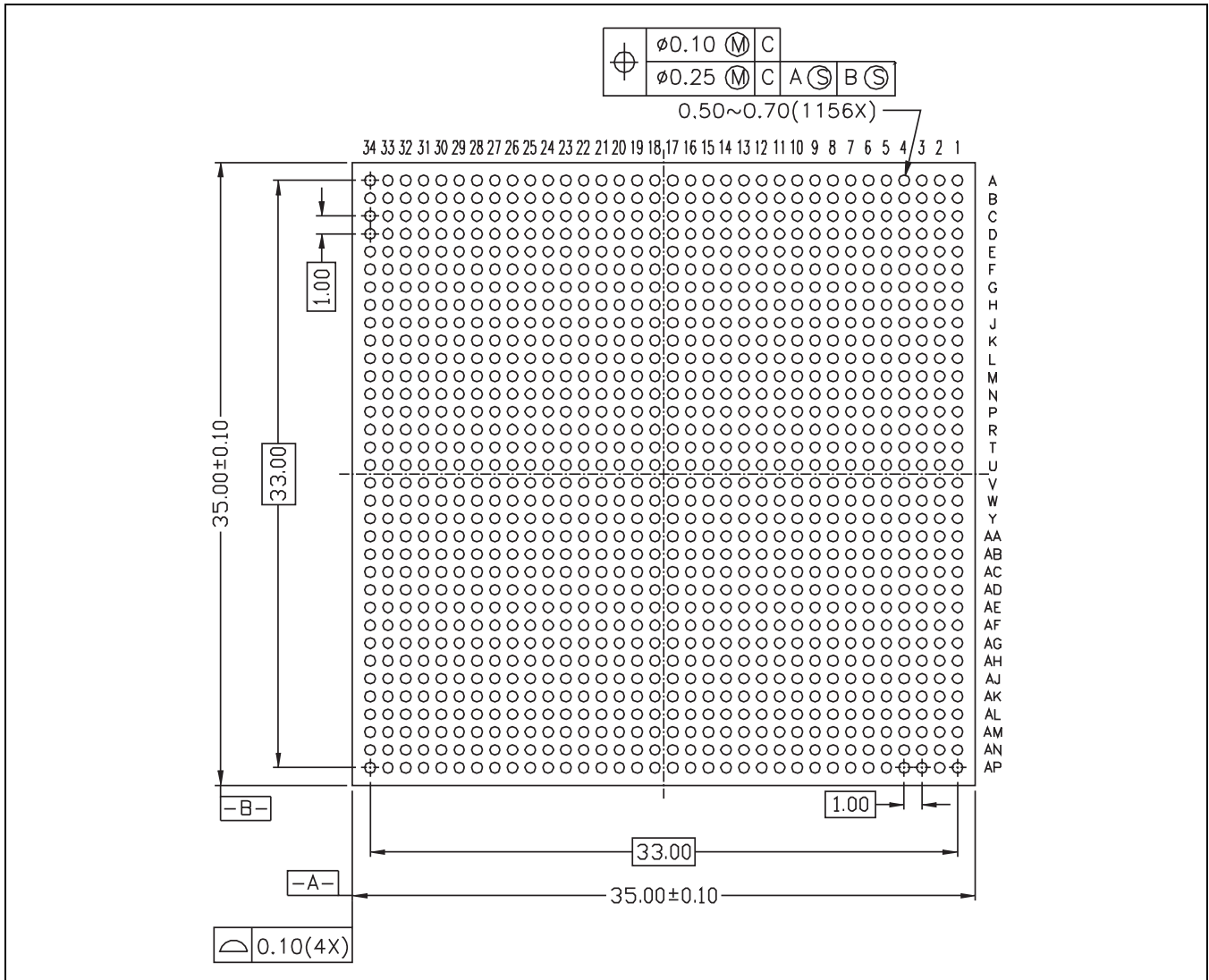


Figure 2-4. M21131/M21151 (-22/-23/-24) Bottom View of Package (in mm)



### 2.1.3 Package Changes

There are some differences between Ceramic and CPCore in package dimension and construction. They are listed below:

Table 2-1. Differences Between Ceramic and CPCore Packaging

Dimension	Differences		Units
	Ceramic	CPCore	
X dimension	35 +0.15/-0.20	35 +/-0.1	mm
Y dimension	35 +0.15/-0.20	35 +/-0.1	mm
Z dimension	3.85 +/-0.26	3.16 +/-0.25	mm
Coplanarity	0.15	0.20	mm

## 2.2 Pinout Diagram and Pin Descriptions

**Table 2-2. BGA Assignments (1 of 8)**

**Note:** For the M21131, the INP/N[72:143] and OUTP/N[72:143] pins are NC (No Connect).

Location	Name	Location	Name	Location	Name	Location	Name
A1	ADDR9	B3	R/XW	C5	XCS	D7	OUTP[136]
A2	DATA6	B4	OUTN[134]	C6	XTEST	D8	OUTP[140]
A3	XRST	B5	OUTN[122]	C7	AV <sub>SS</sub>	D9	OUTP[128]
A4	OUTP[134]	B6	OUTN[138]	C8	AV <sub>DD-IO</sub>	D10	OUTP[116]
A5	OUTP[122]	B7	OUTN[132]	C9	AV <sub>SS</sub>	D11	OUTP[110]
A6	OUTP[138]	B8	OUTN[126]	C10	AV <sub>DD-IO</sub>	D12	OUTP[104]
A7	OUTP[132]	B9	OUTN[120]	C11	AV <sub>SS</sub>	D13	OUTP[98]
A8	OUTP[126]	B10	OUTN[114]	C12	AV <sub>DD-IO</sub>	D14	OUTP[92]
A9	OUTP[120]	B11	OUTN[108]	C13	AV <sub>SS</sub>	D15	OUTP[86]
A10	OUTP[114]	B12	OUTN[102]	C14	AV <sub>DD-IO</sub>	D16	OUTP[80]
A11	OUTP[108]	B13	OUTN[96]	C15	AV <sub>SS</sub>	D17	OUTP[74]
A12	OUTP[102]	B14	OUTN[90]	C16	AV <sub>DD-IO</sub>	D18	OUTP[68]
A13	OUTP[96]	B15	OUTN[84]	C17	AV <sub>SS</sub>	D19	OUTP[62]
A14	OUTP[90]	B16	OUTN[78]	C18	AV <sub>DD-IO</sub>	D20	OUTP[56]
A15	OUTP[84]	B17	OUTN[72]	C19	AV <sub>SS</sub>	D21	OUTP[50]
A16	OUTP[78]	B18	OUTN[66]	C20	AV <sub>DD-IO</sub>	D22	OUTP[44]
A17	OUTP[72]	B19	OUTN[60]	C21	AV <sub>SS</sub>	D23	OUTP[38]
A18	OUTP[66]	B20	OUTN[54]	C22	AV <sub>DD-IO</sub>	D24	OUTP[32]
A19	OUTP[60]	B21	OUTN[48]	C23	AV <sub>SS</sub>	D25	OUTP[26]
A20	OUTP[54]	B22	OUTN[42]	C24	AV <sub>DD-IO</sub>	D26	OUTP[14]
A21	OUTP[48]	B23	OUTN[36]	C25	AV <sub>SS</sub>	D27	OUTP[2]
A22	OUTP[42]	B24	OUTN[30]	C26	AV <sub>DD-IO</sub>	D28	OUTP[34]
A23	OUTP[36]	B25	OUTN[24]	C27	AV <sub>SS</sub>	D29	OUTP[22]
A24	OUTP[30]	B26	OUTN[18]	C28	AV <sub>DD-IO</sub>	D30	OUTP[10]
A25	OUTP[24]	B27	OUTN[12]	C29	AV <sub>SS</sub>	D31	XRSTRX[0]
A26	OUTP[18]	B28	OUTN[6]	C30	MDSPDTEST[[3]	D32	MDSPDTEST[1]
A27	OUTP[12]	B29	OUTN[0]	C31	MDSPDTEST[2]	D33	INN[14]
A28	OUTP[6]	B30	OUTN[20]	C32	PERROR[0]	D34	INP[14]
A29	OUTP[0]	B31	OUTN[8]	C33	INN[0]	E1	INP[5]
A30	OUTP[20]	B32	DIRXN[0]	C34	INP[0]	E2	INN[5]
A31	OUTP[8]	B33	DOTXN[0]	D1	INP[17]	E3	ADDR5
A32	DIRXP[0]	B34	TRIG[0]	D2	INN[17]	E4	ADDR1
A33	DOTXP[0]	C1	INP[7]	D3	XDS/SCLK	E5	ADDR4
A34	CLKTXREF[0]	C2	INN[7]	D4	ADDR7	E6	XSET
B1	ADDR8	C3	AV <sub>SS</sub>	D5	ADDR6	E7	OUTN[136]
B2	DATA7	C4	DATA5	D6	DATA4	E8	OUTN[140]

**Table 2-2. BGA Assignments (2 of 8)**

Location	Name	Location	Name	Location	Name	Location	Name
E9	OUTN[128]	F12	AV <sub>SS</sub>	G15	OUTP[94]	H18	OUTN[76]
E10	OUTN[116]	F13	AV <sub>DD_IO</sub>	G16	OUTP[88]	H19	OUTN[70]
E11	OUTN[110]	F14	AV <sub>SS</sub>	G17	OUTP[82]	H20	OUTN[64]
E12	OUTN[104]	F15	AV <sub>DD_IO</sub>	G18	OUTP[76]	H21	OUTN[58]
E13	OUTN[98]	F16	AV <sub>SS</sub>	G19	OUTP[70]	H22	OUTN[52]
E14	OUTN[92]	F17	AV <sub>DD_IO</sub>	G20	OUTP[64]	H23	OUTN[46]
E15	OUTN[86]	F18	AV <sub>SS</sub>	G21	OUTP[58]	H24	OUTN[40]
E16	OUTN[80]	F19	AV <sub>DD_IO</sub>	G22	OUTP[52]	H25	OUTN[28]
E17	OUTN[74]	F20	AV <sub>SS</sub>	G23	OUTP[46]	H26	OUTN[16]
E18	OUTN[68]	F21	AV <sub>DD_IO</sub>	G24	OUTP[40]	H27	OUTN[4]
E19	OUTN[62]	F22	AV <sub>SS</sub>	G25	OUTP[28]	H28	CLKTXN[0]
E20	OUTN[56]	F23	AV <sub>DD_IO</sub>	G26	OUTP[16]	H29	AV <sub>DD_IO</sub>
E21	OUTN[50]	F24	AV <sub>SS</sub>	G27	OUTP[4]	H30	INN[22]
E22	OUTN[44]	F25	AV <sub>DD_IO</sub>	G28	CLKTXP[0]	H31	INP[22]
E23	OUTN[38]	F26	AV <sub>SS</sub>	G29	AV <sub>SS</sub>	H32	AV <sub>SS</sub>
E24	OUTN[32]	F27	AV <sub>DD_IO</sub>	G30	INN[16]	H33	INN[20]
E25	OUTN[26]	F28	AV <sub>SS</sub>	G31	INP[16]	H34	INP[20]
E26	OUTN[14]	F29	AV <sub>DD_IO</sub>	G32	AV <sub>DD_IO</sub>	J1	INP[25]
E27	OUTN[2]	F30	INN[6]	G33	INN[12]	J2	INN[25]
E28	OUTN[34]	F31	INP[6]	G34	INP[12]	J3	AV <sub>SS</sub>
E29	OUTN[22]	F32	AV <sub>SS</sub>	H1	INP[21]	J4	INP[23]
E30	OUTN[10]	F33	INN[8]	H2	INN[21]	J5	INN[23]
E31	AV <sub>SS</sub>	F34	INP[8]	H3	AV <sub>DD_IO</sub>	J6	AV <sub>DD_IO</sub>
E32	AV <sub>DD_IO</sub>	G1	INP[13]	H4	INP[15]	J7	INP[3]
E33	INN[4]	G2	INN[13]	H5	INN[15]	J8	INN[3]
E34	INP[4]	G3	AV <sub>SS</sub>	H6	DATA1	J9	AV <sub>SS</sub>
F1	INP[9]	G4	INP[1]	H7	MDSPDTEST[5]	J10	MDSPDTEST[29]
F2	INN[9]	G5	INN[1]	H8	OUTN[142]	J11	AV <sub>SS</sub>
F3	ADDR2	G6	XINDIS	H9	OUTN[130]	J12	AV <sub>DD_IO</sub>
F4	XOUTDIS	G7	MDSPDTEST[4]	H10	OUTN[124]	J13	AV <sub>DD_IO</sub>
F5	ADDR0	G8	OUTP[142]	H11	OUTN[118]	J14	AV <sub>DD_CORE</sub>
F6	ADDR3	G9	OUTP[130]	H12	OUTN[112]	J15	AV <sub>DD_CORE</sub>
F7	DATA2	G10	OUTP[124]	H13	OUTN[106]	J16	AV <sub>DD_IO</sub>
F8	MDSPDTEST[28]	G11	OUTP[118]	H14	OUTN[100]	J17	AV <sub>DD_IO</sub>
F9	AV <sub>DD_IO</sub>	G12	OUTP[112]	H15	OUTN[94]	J18	AV <sub>DD_CORE</sub>
F10	AV <sub>SS</sub>	G13	OUTP[106]	H16	OUTN[88]	J19	AV <sub>DD_CORE</sub>
F11	AV <sub>DD_IO</sub>	G14	OUTP[100]	H17	OUTN[82]	J20	AV <sub>DD_IO</sub>



**Table 2-2. BGA Assignments (3 of 8)**

Location	Name
J21	AV <sub>DD</sub> _IO
J22	AV <sub>DD</sub> _CORE
J23	AV <sub>DD</sub> _CORE
J24	AV <sub>SS</sub>
J25	AV <sub>DD</sub> _IO
J26	AV <sub>SS</sub>
J27	INN[2]
J28	INP[2]
J29	AV <sub>SS</sub>
J30	INN[30]
J31	INP[30]
J32	AV <sub>DD</sub> _IO
J33	INN[24]
J34	INP[24]
K1	INP[29]
K2	INN[29]
K3	AV <sub>DD</sub> _IO
K4	INP[31]
K5	INN[31]
K6	AV <sub>SS</sub>
K7	INP[11]
K8	INN[11]
K9	N/C
K10	SER/XPAR
K11	DATA3
K12	AV <sub>SS</sub>
K13	AV <sub>SS</sub>
K14	AV <sub>SS</sub>
K15	AV <sub>SS</sub>
K16	AV <sub>SS</sub>
K17	AV <sub>SS</sub>
K18	AV <sub>SS</sub>
K19	AV <sub>SS</sub>
K20	AV <sub>SS</sub>
K21	AV <sub>SS</sub>
K22	AV <sub>SS</sub>
K23	AV <sub>SS</sub>

Location	Name
K24	MDSPDTEST[32]
K25	XENRX[0]
K26	AV <sub>DD</sub> _IO
K27	INN[10]
K28	INP[10]
K29	AV <sub>DD</sub> _IO
K30	INN[32]
K31	INP[32]
K32	AV <sub>SS</sub>
K33	INN[28]
K34	INP[28]
L1	INP[37]
L2	INN[37]
L3	AV <sub>SS</sub>
L4	INP[33]
L5	INN[33]
L6	AV <sub>DD</sub> _IO
L7	INP[19]
L8	INN[19]
L9	DV <sub>SS</sub> _IO
L10	LOS
L11	DATA0
L12	AV <sub>SS</sub>
L13	AV <sub>SS</sub>
L14	AV <sub>SS</sub>
L15	AV <sub>SS</sub>
L16	AV <sub>SS</sub>
L17	AV <sub>SS</sub>
L18	AV <sub>SS</sub>
L19	AV <sub>SS</sub>
L20	AV <sub>SS</sub>
L21	AV <sub>SS</sub>
L22	AV <sub>SS</sub>
L23	AV <sub>SS</sub>
L24	MDSPDTEST[33]
L25	XENTX[0]
L26	AV <sub>SS</sub>

Location	Name
L27	INN[18]
L28	INP[18]
L29	AV <sub>SS</sub>
L30	INN[38]
L31	INP[38]
L32	AV <sub>DD</sub> _IO
L33	INN[36]
L34	INP[36]
M1	INP[41]
M2	INN[41]
M3	AV <sub>DD</sub> _IO
M4	INP[39]
M5	INN[39]
M6	AV <sub>SS</sub>
M7	INP[27]
M8	INN[27]
M9	AV <sub>DD</sub> _CORE
M10	DV <sub>DD</sub> _IO
M11	AV <sub>SS</sub>
M12	AV <sub>DD</sub> _IO
M13	AV <sub>DD</sub> _IO
M14	AV <sub>SS</sub>
M15	AV <sub>SS</sub>
M16	AV <sub>DD</sub> _CORE
M17	AV <sub>DD</sub> _CORE
M18	AV <sub>DD</sub> _CORE
M19	AV <sub>DD</sub> _CORE
M20	AV <sub>SS</sub>
M21	AV <sub>SS</sub>
M22	AV <sub>DD</sub> _IO
M23	AV <sub>DD</sub> _IO
M24	AV <sub>SS</sub>
M25	AV <sub>SS</sub>
M26	AV <sub>DD</sub> _CORE
M27	INN[26]
M28	INP[26]
M29	AV <sub>DD</sub> _IO

Location	Name
M30	INN[46]
M31	INP[46]
M32	AV <sub>SS</sub>
M33	INN[40]
M34	INP[40]
N1	INP[45]
N2	INN[45]
N3	AV <sub>SS</sub>
N4	INP[47]
N5	INN[47]
N6	AV <sub>DD</sub> _IO
N7	INP[35]
N8	INN[35]
N9	AV <sub>DD</sub> _CORE
N10	AV <sub>SS</sub>
N11	AV <sub>SS</sub>
N12	AV <sub>DD</sub> _IO
N13	AV <sub>DD</sub> _IO
N14	AV <sub>SS</sub>
N15	AV <sub>SS</sub>
N16	AV <sub>DD</sub> _CORE
N17	AV <sub>DD</sub> _CORE
N18	AV <sub>DD</sub> _CORE
N19	AV <sub>DD</sub> _CORE
N20	AV <sub>SS</sub>
N21	AV <sub>SS</sub>
N22	AV <sub>DD</sub> _IO
N23	AV <sub>DD</sub> _IO
N24	AV <sub>SS</sub>
N25	AV <sub>SS</sub>
N26	AV <sub>DD</sub> _CORE
N27	INN[34]
N28	INP[34]
N29	AV <sub>SS</sub>
N30	INN[48]
N31	INP[48]
N32	AV <sub>DD</sub> _IO

**Table 2-2. BGA Assignments (4 of 8)**

Location	Name
N33	INN[44]
N34	INP[44]
P1	INP[53]
P2	INN[53]
P3	AV <sub>DD</sub> _IO
P4	INP[49]
P5	INN[49]
P6	AV <sub>SS</sub>
P7	INP[43]
P8	INN[43]
P9	AV <sub>DD</sub> _IO
P10	AV <sub>SS</sub>
P11	AV <sub>SS</sub>
P12	AV <sub>DD</sub> _IO
P13	AV <sub>DD</sub> _IO
P14	AV <sub>SS</sub>
P15	AV <sub>SS</sub>
P16	AV <sub>DD</sub> _CORE
P17	AV <sub>DD</sub> _CORE
P18	AV <sub>DD</sub> _CORE
P19	AV <sub>DD</sub> _CORE
P20	AV <sub>SS</sub>
P21	AV <sub>SS</sub>
P22	AV <sub>DD</sub> _IO
P23	AV <sub>DD</sub> _IO
P24	AV <sub>SS</sub>
P25	AV <sub>SS</sub>
P26	AV <sub>DD</sub> _IO
P27	INN[42]
P28	INP[42]
P29	AV <sub>DD</sub> _IO
P30	INN[54]
P31	INP[54]
P32	AV <sub>SS</sub>
P33	INN[52]
P34	INP[52]
R1	INP[57]

Location	Name
R2	INN[57]
R3	AV <sub>SS</sub>
R4	INP[55]
R5	INN[55]
R6	AV <sub>DD</sub> _IO
R7	INP[51]
R8	INN[51]
R9	AV <sub>DD</sub> _IO
R10	AV <sub>SS</sub>
R11	AV <sub>SS</sub>
R12	AV <sub>DD</sub> _IO
R13	AV <sub>DD</sub> _IO
R14	AV <sub>SS</sub>
R15	AV <sub>SS</sub>
R16	AV <sub>DD</sub> _CORE
R17	AV <sub>DD</sub> _CORE
R18	AV <sub>DD</sub> _CORE
R19	AV <sub>DD</sub> _CORE
R20	AV <sub>SS</sub>
R21	AV <sub>SS</sub>
R22	AV <sub>DD</sub> _IO
R23	AV <sub>DD</sub> _IO
R24	AV <sub>SS</sub>
R25	AV <sub>SS</sub>
R26	AV <sub>DD</sub> _IO
R27	INN[50]
R28	INP[50]
R29	AV <sub>SS</sub>
R30	INN[62]
R31	INP[62]
R32	AV <sub>DD</sub> _IO
R33	INN[56]
R34	INP[56]
T1	INP[61]
T2	INN[61]
T3	AV <sub>DD</sub> _IO
T4	INP[63]

Location	Name
T5	INN[63]
T6	AV <sub>SS</sub>
T7	INP[59]
T8	INN[59]
T9	AV <sub>DD</sub> _CORE
T10	AV <sub>SS</sub>
T11	AV <sub>SS</sub>
T12	AV <sub>DD</sub> _IO
T13	AV <sub>DD</sub> _IO
T14	AV <sub>SS</sub>
T15	AV <sub>SS</sub>
T16	AV <sub>DD</sub> _CORE
T17	AV <sub>DD</sub> _CORE
T18	AV <sub>DD</sub> _CORE
T19	AV <sub>DD</sub> _CORE
T20	AV <sub>SS</sub>
T21	AV <sub>SS</sub>
T22	AV <sub>DD</sub> _IO
T23	AV <sub>DD</sub> _IO
T24	AV <sub>SS</sub>
T25	AV <sub>SS</sub>
T26	AV <sub>DD</sub> _CORE
T27	INN[58]
T28	INP[58]
T29	AV <sub>DD</sub> _IO
T30	INN[64]
T31	INP[64]
T32	AV <sub>SS</sub>
T33	INN[60]
T34	INP[60]
U1	INP[69]
U2	INN[69]
U3	AV <sub>SS</sub>
U4	INP[65]
U5	INN[65]
U6	AV <sub>DD</sub> _IO
U7	INP[67]

Location	Name
U8	INN[67]
U9	AV <sub>DD</sub> _CORE
U10	AV <sub>SS</sub>
U11	AV <sub>SS</sub>
U12	AV <sub>DD</sub> _IO
U13	AV <sub>DD</sub> _IO
U14	AV <sub>SS</sub>
U15	AV <sub>SS</sub>
U16	AV <sub>DD</sub> _CORE
U17	AV <sub>DD</sub> _CORE
U18	AV <sub>DD</sub> _CORE
U19	AV <sub>DD</sub> _CORE
U20	AV <sub>SS</sub>
U21	AV <sub>SS</sub>
U22	AV <sub>DD</sub> _IO
U23	AV <sub>DD</sub> _IO
U24	AV <sub>SS</sub>
U25	AV <sub>SS</sub>
U26	AV <sub>DD</sub> _CORE
U27	INN[66]
U28	INP[66]
U29	AV <sub>SS</sub>
U30	INN[70]
U31	INP[70]
U32	AV <sub>DD</sub> _IO
U33	INN[68]
U34	INP[68]
V1	INP[73]
V2	INN[73]
V3	AV <sub>DD</sub> _IO
V4	INP[71]
V5	INN[71]
V6	AV <sub>SS</sub>
V7	INP[75]
V8	INN[75]
V9	AV <sub>DD</sub> _IO
V10	AV <sub>SS</sub>

**Table 2-2. BGA Assignments (5 of 8)**

Location	Name	Location	Name	Location	Name	Location	Name
V11	AV <sub>SS</sub>	W14	AV <sub>SS</sub>	Y17	AV <sub>DD</sub> _CORE	AA20	AV <sub>SS</sub>
V12	AV <sub>DD</sub> _IO	W15	AV <sub>SS</sub>	Y18	AV <sub>DD</sub> _CORE	AA21	AV <sub>SS</sub>
V13	AV <sub>DD</sub> _IO	W16	AV <sub>DD</sub> _CORE	Y19	AV <sub>DD</sub> _CORE	AA22	AV <sub>DD</sub> _IO
V14	AV <sub>SS</sub>	W17	AV <sub>DD</sub> _CORE	Y20	AV <sub>SS</sub>	AA23	AV <sub>DD</sub> _IO
V15	AV <sub>SS</sub>	W18	AV <sub>DD</sub> _CORE	Y21	AV <sub>SS</sub>	AA24	AV <sub>SS</sub>
V16	AV <sub>DD</sub> _CORE	W19	AV <sub>DD</sub> _CORE	Y22	AV <sub>DD</sub> _IO	AA25	AV <sub>SS</sub>
V17	AV <sub>DD</sub> _CORE	W20	AV <sub>SS</sub>	Y23	AV <sub>DD</sub> _IO	AA26	AV <sub>DD</sub> _CORE
V18	AV <sub>DD</sub> _CORE	W21	AV <sub>SS</sub>	Y24	AV <sub>SS</sub>	AA27	INN[98]
V19	AV <sub>DD</sub> _CORE	W22	AV <sub>DD</sub> _IO	Y25	AV <sub>SS</sub>	AA28	INP[98]
V20	AV <sub>SS</sub>	W23	AV <sub>DD</sub> _IO	Y26	AV <sub>DD</sub> _CORE	AA29	AV <sub>SS</sub>
V21	AV <sub>SS</sub>	W24	AV <sub>SS</sub>	Y27	INN[90]	AA30	INN[94]
V22	AV <sub>DD</sub> _IO	W25	AV <sub>SS</sub>	Y28	INP[90]	AA31	INP[94]
V23	AV <sub>DD</sub> _IO	W26	AV <sub>DD</sub> _IO	Y29	AV <sub>DD</sub> _IO	AA32	AV <sub>DD</sub> _IO
V24	AV <sub>SS</sub>	W27	INN[82]	Y30	INN[86]	AA33	INN[88]
V25	AV <sub>SS</sub>	W28	INP[82]	Y31	INP[86]	AA34	INP[88]
V26	AV <sub>DD</sub> _IO	W29	AV <sub>SS</sub>	Y32	AV <sub>SS</sub>	AB1	INP[93]
V27	INN[74]	W30	INN[80]	Y33	INN[84]	AB2	INN[93]
V28	INP[74]	W31	INP[80]	Y34	INP[84]	AB3	AV <sub>DD</sub> _IO
V29	AV <sub>DD</sub> _IO	W32	AV <sub>DD</sub> _IO	AA1	INP[89]	AB4	INP[95]
V30	INN[78]	W33	INN[76]	AA2	INN[89]	AB5	INN[95]
V31	INP[78]	W34	INP[76]	AA3	AV <sub>SS</sub>	AB6	AV <sub>SS</sub>
V32	AV <sub>SS</sub>	Y1	INP[85]	AA4	INP[87]	AB7	INP[107]
V33	INN[72]	Y2	INN[85]	AA5	INN[87]	AB8	INN[107]
V34	INP[72]	Y3	AV <sub>DD</sub> _IO	AA6	AV <sub>DD</sub> _IO	AB9	AV <sub>DD</sub> _IO
W1	INP[77]	Y4	INP[81]	AA7	INP[99]	AB10	AV <sub>SS</sub>
W2	INN[77]	Y5	INN[81]	AA8	INN[99]	AB11	AV <sub>SS</sub>
W3	AV <sub>SS</sub>	Y6	AV <sub>SS</sub>	AA9	AV <sub>DD</sub> _CORE	AB12	AV <sub>DD</sub> _IO
W4	INP[79]	Y7	INP[91]	AA10	AV <sub>SS</sub>	AB13	AV <sub>DD</sub> _IO
W5	INN[79]	Y8	INN[91]	AA11	AV <sub>SS</sub>	AB14	AV <sub>SS</sub>
W6	AV <sub>DD</sub> _IO	Y9	AV <sub>DD</sub> _CORE	AA12	AV <sub>DD</sub> _IO	AB15	AV <sub>SS</sub>
W7	INP[83]	Y10	AV <sub>SS</sub>	AA13	AV <sub>DD</sub> _IO	AB16	AV <sub>DD</sub> _CORE
W8	INN[83]	Y11	AV <sub>SS</sub>	AA14	AV <sub>SS</sub>	AB17	AV <sub>DD</sub> _CORE
W9	AV <sub>DD</sub> _IO	Y12	AV <sub>DD</sub> _IO	AA15	AV <sub>SS</sub>	AB18	AV <sub>DD</sub> _CORE
W10	AV <sub>SS</sub>	Y13	AV <sub>DD</sub> _IO	AA16	AV <sub>DD</sub> _CORE	AB19	AV <sub>DD</sub> _CORE
W11	AV <sub>SS</sub>	Y14	AV <sub>SS</sub>	AA17	AV <sub>DD</sub> _CORE	AB20	AV <sub>SS</sub>
W12	AV <sub>DD</sub> _IO	Y15	AV <sub>SS</sub>	AA18	AV <sub>DD</sub> _CORE	AB21	AV <sub>SS</sub>
W13	AV <sub>DD</sub> _IO	Y16	AV <sub>DD</sub> _CORE	AA19	AV <sub>DD</sub> _CORE	AB22	AV <sub>DD</sub> _IO

**Table 2-2. BGA Assignments (6 of 8)**

Location	Name	Location	Name	Location	Name	Location	Name
AB23	AV <sub>DD</sub> _IO	AC26	AV <sub>DD</sub> _IO	AD29	AV <sub>DD</sub> _IO	AE32	AV <sub>DD</sub> _IO
AB24	AV <sub>SS</sub>	AC27	INN[114]	AD30	INN[110]	AE33	INN[108]
AB25	AV <sub>SS</sub>	AC28	INP[114]	AD31	INP[110]	AE34	INP[108]
AB26	AV <sub>DD</sub> _IO	AC29	AV <sub>SS</sub>	AD32	AV <sub>SS</sub>	AF1	INP[117]
AB27	INN[106]	AC30	INN[102]	AD33	INN[104]	AF2	INN[117]
AB28	INP[106]	AC31	INP[102]	AD34	INP[104]	AF3	AV <sub>DD</sub> _IO
AB29	AV <sub>DD</sub> _IO	AC32	AV <sub>DD</sub> _IO	AE1	INP[109]	AF4	INP[113]
AB30	INN[96]	AC33	INN[100]	AE2	INN[109]	AF5	INN[113]
AB31	INP[96]	AC34	INP[100]	AE3	AV <sub>SS</sub>	AF6	AV <sub>SS</sub>
AB32	AV <sub>SS</sub>	AD1	INP[105]	AE4	INP[111]	AF7	INP[139]
AB33	INN[92]	AD2	INN[105]	AE5	INN[111]	AF8	INN[139]
AB34	INP[92]	AD3	AV <sub>DD</sub> _IO	AE6	AV <sub>DD</sub> _IO	AF9	AV <sub>SS</sub>
AC1	INP[101]	AD4	INP[103]	AE7	INP[131]	AF10	AV <sub>DD</sub> _IO
AC2	INN[101]	AD5	INN[103]	AE8	INN[131]	AF11	AV <sub>SS</sub>
AC3	AV <sub>SS</sub>	AD6	AV <sub>SS</sub>	AE9	AV <sub>DD</sub> _IO	AF12	AV <sub>DD</sub> _IO
AC4	INP[97]	AD7	INP[123]	AE10	TRIG[1]	AF13	AV <sub>DD</sub> _IO
AC5	INN[97]	AD8	INN[123]	AE11	MDSPDTEST[30]	AF14	AV <sub>DD</sub> _CORE
AC6	AV <sub>DD</sub> _IO	AD9	AV <sub>SS</sub>	AE12	AV <sub>SS</sub>	AF15	AV <sub>DD</sub> _CORE
AC7	INP[115]	AD10	PERROR[1]	AE13	AV <sub>SS</sub>	AF16	AV <sub>DD</sub> _IO
AC8	INN[115]	AD11	MDSPDTEST[31]	AE14	AV <sub>SS</sub>	AF17	AV <sub>DD</sub> _IO
AC9	AV <sub>DD</sub> _IO	AD12	AV <sub>SS</sub>	AE15	AV <sub>SS</sub>	AF18	AV <sub>DD</sub> _CORE
AC10	AV <sub>SS</sub>	AD13	AV <sub>SS</sub>	AE16	AV <sub>SS</sub>	AF19	AV <sub>DD</sub> _CORE
AC11	AV <sub>SS</sub>	AD14	AV <sub>SS</sub>	AE17	AV <sub>SS</sub>	AF20	AV <sub>DD</sub> _IO
AC12	AV <sub>DD</sub> _IO	AD15	AV <sub>SS</sub>	AE18	AV <sub>SS</sub>	AF21	AV <sub>DD</sub> _IO
AC13	AV <sub>DD</sub> _IO	AD16	AV <sub>SS</sub>	AE19	AV <sub>SS</sub>	AF22	AV <sub>DD</sub> _CORE
AC14	AV <sub>SS</sub>	AD17	AV <sub>SS</sub>	AE20	AV <sub>SS</sub>	AF23	AV <sub>DD</sub> _CORE
AC15	AV <sub>SS</sub>	AD18	AV <sub>SS</sub>	AE21	AV <sub>SS</sub>	AF24	AV <sub>DD</sub> _IO
AC16	AV <sub>DD</sub> _CORE	AD19	AV <sub>SS</sub>	AE22	AV <sub>SS</sub>	AF25	AV <sub>DD</sub> _IO
AC17	AV <sub>DD</sub> _CORE	AD20	AV <sub>SS</sub>	AE23	AV <sub>SS</sub>	AF26	MDSPDTEST[12]
AC18	AV <sub>DD</sub> _CORE	AD21	AV <sub>SS</sub>	AE24	AV <sub>SS</sub>	AF27	INN[138]
AC19	AV <sub>DD</sub> _CORE	AD22	AV <sub>SS</sub>	AE25	AV <sub>SS</sub>	AF28	INP[138]
AC20	AV <sub>SS</sub>	AD23	AV <sub>SS</sub>	AE26	MDSPDTEST[11]	AF29	AV <sub>DD</sub> _IO
AC21	AV <sub>SS</sub>	AD24	AV <sub>SS</sub>	AE27	INN[130]	AF30	INN[118]
AC22	AV <sub>DD</sub> _IO	AD25	AV <sub>SS</sub>	AE28	INP[130]	AF31	INP[118]
AC23	AV <sub>DD</sub> _IO	AD26	AV <sub>DD</sub> _IO	AE29	AV <sub>SS</sub>	AF32	AV <sub>SS</sub>
AC24	AV <sub>SS</sub>	AD27	INN[122]	AE30	INN[112]	AF33	INN[116]
AC25	AV <sub>SS</sub>	AD28	INP[122]	AE31	INP[112]	AF34	INP[116]

**Table 2-2. BGA Assignments (7 of 8)**

Location	Name	Location	Name	Location	Name	Location	Name
AG1	INP[121]	AH4	INP[127]	AJ7	AV <sub>SS</sub>	AK10	OUTN[117]
AG2	INN[121]	AH5	INN[127]	AJ8	AV <sub>DD-IO</sub>	AK11	OUTN[111]
AG3	AV <sub>SS</sub>	AH6	AV <sub>SS</sub>	AJ9	AV <sub>SS</sub>	AK12	OUTN[105]
AG4	INP[119]	AH7	CLKTXP[1]	AJ10	AV <sub>DD-IO</sub>	AK13	OUTN[99]
AG5	INN[119]	AH8	OUTP[143]	AJ11	AV <sub>SS</sub>	AK14	OUTN[93]
AG6	AV <sub>DD-IO</sub>	AH9	OUTP[131]	AJ12	AV <sub>DD-IO</sub>	AK15	OUTN[87]
AG7	CLKTXN[1]	AH10	OUTP[119]	AJ13	AV <sub>SS</sub>	AK16	OUTN[81]
AG8	OUTN[143]	AH11	OUTP[113]	AJ14	AV <sub>DD-IO</sub>	AK17	OUTN[75]
AG9	OUTN[131]	AH12	OUTP[107]	AJ15	AV <sub>SS</sub>	AK18	OUTN[69]
AG10	OUTN[119]	AH13	OUTP[101]	AJ16	AV <sub>DD-IO</sub>	AK19	OUTN[63]
AG11	OUTN[113]	AH14	OUTP[95]	AJ17	AV <sub>SS</sub>	AK20	OUTN[57]
AG12	OUTN[107]	AH15	OUTP[89]	AJ18	AV <sub>DD-IO</sub>	AK21	OUTN[51]
AG13	OUTN[101]	AH16	OUTP[83]	AJ19	AV <sub>SS</sub>	AK22	OUTN[45]
AG14	OUTN[95]	AH17	OUTP[77]	AJ20	AV <sub>DD-IO</sub>	AK23	OUTN[39]
AG15	OUTN[89]	AH18	OUTP[71]	AJ21	AV <sub>SS</sub>	AK24	OUTN[33]
AG16	OUTN[83]	AH19	OUTP[65]	AJ22	AV <sub>DD-IO</sub>	AK25	OUTN[27]
AG17	OUTN[77]	AH20	OUTP[59]	AJ23	AV <sub>SS</sub>	AK26	OUTN[15]
AG18	OUTN[71]	AH21	OUTP[53]	AJ24	AV <sub>DD-IO</sub>	AK27	OUTN[3]
AG19	OUTN[65]	AH22	OUTP[47]	AJ25	AV <sub>SS</sub>	AK28	OUTN[29]
AG20	OUTN[59]	AH23	OUTP[41]	AJ26	AV <sub>DD-IO</sub>	AK29	OUTN[17]
AG21	OUTN[53]	AH24	OUTP[35]	AJ27	AV <sub>SS</sub>	AK30	MDSPDTEST[21]
AG22	OUTN[47]	AH25	OUTP[23]	AJ28	AV <sub>DD-IO</sub>	AK31	MDSPDTEST[9]
AG23	OUTN[41]	AH26	OUTP[11]	AJ29	MDSPDTEST[24]	AK32	MDSPDTEST[6]
AG24	OUTN[35]	AH27	OUTP[5]	AJ30	INN[142]	AK33	INN[136]
AG25	OUTN[23]	AH28	MDSPDTEST[18]	AJ31	INP[142]	AK34	INP[136]
AG26	OUTN[11]	AH29	MDSPDTEST[23]	AJ32	AV <sub>DD-IO</sub>	AL1	INP[141]
AG27	OUTN[5]	AH30	INN[128]	AJ33	INN[132]	AL2	INN[141]
AG28	MDSPDTEST[17]	AH31	INP[128]	AJ34	INP[132]	AL3	MDSPDTEST[27]
AG29	AV <sub>SS</sub>	AH32	AV <sub>SS</sub>	AK1	INP[137]	AL4	XENRX[1]
AG30	INN[126]	AH33	INN[124]	AK2	INN[137]	AL5	MDSPDTEST[25]
AG31	INP[126]	AH34	INP[124]	AK3	XRSTRX[1]	AL6	OUTP[137]
AG32	AV <sub>DD-IO</sub>	AJ1	INP[133]	AK4	INP[143]	AL7	OUTP[125]
AG33	INN[120]	AJ2	INN[133]	AK5	INN[143]	AL8	OUTP[141]
AG34	INP[120]	AJ3	AV <sub>SS</sub>	AK6	OUTN[137]	AL9	OUTP[129]
AH1	INP[125]	AJ4	INP[135]	AK7	OUTN[125]	AL10	OUTP[117]
AH2	INN[125]	AJ5	INN[135]	AK8	OUTN[141]	AL11	OUTP[111]
AH3	AV <sub>DD-IO</sub>	AJ6	AV <sub>DD-IO</sub>	AK9	OUTN[129]	AL12	OUTP[105]

**Table 2-2. BGA Assignments (8 of 8)**

Location	Name
AL13	OUTP[99]
AL14	OUTP[93]
AL15	OUTP[87]
AL16	OUTP[81]
AL17	OUTP[75]
AL18	OUTP[69]
AL19	OUTP[63]
AL20	OUTP[57]
AL21	OUTP[51]
AL22	OUTP[45]
AL23	OUTP[39]
AL24	OUTP[33]
AL25	OUTP[27]
AL26	OUTP[15]
AL27	OUTP[3]
AL28	OUTP[29]
AL29	OUTP[17]
AL30	MDSPDTEST[22]
AL31	MDSPDTEST[8]
AL32	MDSPDTEST[7]
AL33	INN[140]
AL34	INP[140]
AM1	INP[129]
AM2	INN[129]
AM3	CLKTXREF[1]
AM4	XENTX[1]
AM5	MDSPDTEST[26]
AM6	AVSS
AM7	AV <sub>DD</sub> _IO
AM8	AV <sub>SS</sub>
AM9	AV <sub>DD</sub> _IO

Location	Name
AM10	AV <sub>SS</sub>
AM11	AV <sub>DD</sub> _IO
AM12	AV <sub>SS</sub>
AM13	AV <sub>DD</sub> _IO
AM14	AV <sub>SS</sub>
AM15	AV <sub>DD</sub> _IO
AM16	AV <sub>SS</sub>
AM17	AV <sub>DD</sub> _IO
AM18	AV <sub>SS</sub>
AM19	AV <sub>DD</sub> _IO
AM20	AV <sub>SS</sub>
AM21	AV <sub>DD</sub> _IO
AM22	AV <sub>SS</sub>
AM23	AV <sub>DD</sub> _IO
AM24	AV <sub>SS</sub>
AM25	AV <sub>DD</sub> _IO
AM26	AV <sub>SS</sub>
AM27	AV <sub>DD</sub> _IO
AM28	AV <sub>SS</sub>
AM29	AV <sub>DD</sub> _IO
AM30	AV <sub>SS</sub>
AM31	MDSPDTEST[19]
AM32	MDSPDTEST[10]
AM33	INN[134]
AM34	INP[134]
AN1	DOTXN[1]
AN2	DIRXN[1]
AN3	OUTN[135]
AN4	OUTN[123]
AN5	OUTN[139]
AN6	OUTN[133]

Location	Name
AN7	OUTN[127]
AN8	OUTN[121]
AN9	OUTN[115]
AN10	OUTN[109]
AN11	OUTN[103]
AN12	OUTN[97]
AN13	OUTN[91]
AN14	OUTN[85]
AN15	OUTN[79]
AN16	OUTN[73]
AN17	OUTN[67]
AN18	OUTN[61]
AN19	OUTN[55]
AN20	OUTN[49]
AN21	OUTN[43]
AN22	OUTN[37]
AN23	OUTN[31]
AN24	OUTN[25]
AN25	OUTN[19]
AN26	OUTN[13]
AN27	OUTN[7]
AN28	OUTN[1]
AN29	OUTN[21]
AN30	OUTN[9]
AN31	MDSPDTEST[20]
AN32	AV <sub>DD</sub> _IO
AN33	N/C
AN34	MDSPDTEST[13]
AP1	DOTXP[1]
AP2	DIRXP[1]
AP3	OUTP[135]

Location	Name
AP4	OUTP[123]
AP5	OUTP[139]
AP6	OUTP[133]
AP7	OUTP[127]
AP8	OUTP[121]
AP9	OUTP[115]
AP10	OUTP[109]
AP11	OUTP[103]
AP12	OUTP[97]
AP13	OUTP[91]
AP14	OUTP[85]
AP15	OUTP[79]
AP16	OUTP[73]
AP17	OUTP[67]
AP18	OUTP[61]
AP19	OUTP[55]
AP20	OUTP[49]
AP21	OUTP[43]
AP22	OUTP[37]
AP23	OUTP[31]
AP24	OUTP[25]
AP25	OUTP[19]
AP26	OUTP[13]
AP27	OUTP[7]
AP28	OUTP[1]
AP29	OUTP[21]
AP30	OUTP[9]
AP31	MDSPDTEST[16]
AP32	MDSPDTEST[15]
AP33	RXREFCLK
AP34	MDSPDTEST[14]

**Table 2-3. Digital Power Connections**

Location	Connection
L9	DV <sub>SS_IO</sub>
M10	DV <sub>DD_IO</sub>

**Table 2-4. BGA Connections to AV<sub>DD\_IO</sub>**

Ball Location											
AA12	AC9	AF12	AJ12	AM17	C22	F29	K3	P3	R32	V12	Y12
AA13	AC12	AF13	AJ14	AM19	C24	G32	L6	P9	T3	V13	Y13
AA22	AC13	AF16	AJ16	AM21	C26	H3	L32	P12	T12	V22	Y22
AA23	AC22	AF17	AJ18	AM23	C28	H29	M12	P13	T13	V23	Y23
AA32	AC23	AF20	AJ20	AM25	E32	J6	M13	P22	T22	V26	Y29
AA6	AC26	AF21	AJ22	AM27	F09	J12	M22	P23	T23	V29	—
AB3	AC32	AF24	AJ24	AM29	F11	J13	M23	P26	T29	W6	—
AB9	AD03	AF25	AJ26	AN32	F13	J16	M29	P29	U6	W9	—
AB12	AD26	AF29	AJ28	C8	F15	J17	M3	R6	U12	W12	—
AB13	AD29	AG06	AJ32	C10	F17	J20	N6	R9	U13	W13	—
AB22	AE6	AG32	AM07	C12	F19	J21	N12	R12	U22	W22	—
AB23	AE9	AH3	AM9	C14	F21	J25	N13	R13	U23	W23	—
AB26	AE32	AJ6	AM11	C16	F23	J32	N22	R22	U32	W26	—
AB29	AF3	AJ8	AM13	C18	F25	K26	N23	R23	V3	W32	—
AC6	AF10	AJ10	AM15	C20	F27	K29	N32	R26	V9	Y3	—

**Table 2-5. BGA Connections to AV<sub>DD\_CORE</sub>**

Ball Locations					
AA9	AC18	J22	N19	T17	V18
AA16	AC19	J23	N26	T18	V19
AA17	AF14	M9	P16	T19	W16
AA18	AF15	M16	P17	T26	W17
AA19	AF18	M17	P18	U9	W18
AA26	AF19	M18	P19	U16	W19
AB16	AF22	M19	R16	U17	Y9
AB17	AF23	M26	R17	U18	Y16
AB18	J14	N9	R18	U19	Y17
AB19	J15	N16	R19	U26	Y18
AC16	J18	N17	T9	V16	Y19
AC17	J19	N18	T16	V17	Y26

## 2.3 Pin Definitions

**Table 2-6. Power Pins**

Pin Name	Function	Type
AV <sub>DD</sub> _IO	Analog I/O positive supply	Power
AV <sub>DD</sub> _CORE	Analog core positive supply	Power
AV <sub>SS</sub>	Device ground	Power
DV <sub>DD</sub> _IO	Digital I/O positive supply	Power
DV <sub>SS</sub> _IO	Digital I/O negative supply	Power

**Table 2-7. High-Speed Signal Pins (1 of 2)**

Pin Name	Function	Termination	Type
INP[71:0] / INP[143:0]	Positive differential input data	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
INN[71:0] / INN[143:0]	Negative differential input data	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
OUTP[71:0] / OUTP[143:0]	Positive differential output data	50Ω internal pull-up to AV <sub>DD</sub> _IO	Output/PCML
OUTN[71:0] / OUTN[143:0]	Negative differential output data	50Ω internal pull-up to AV <sub>DD</sub> _IO	Output/PCML
XINDIS	Hardware disable of all inputs (active low)	100 kΩ internal pull-down	Input/CMOS
XOUTDIS	Hardware disable of all outputs (active low)	100 kΩ internal pull-down	Input/CMOS
A[9:0]	10 bit parallel address (bit 9: MSB, bit 0: LSB)	100 kΩ internal pull-up	Input/CMOS
D[5:0]	6 low bits of 8 bit parallel data (bit 0: LSB)	100 kΩ internal pull-up	I/O/CMOS
D[6]/SDI	7th bit of parallel data or serial data input	100 kΩ internal pull-up	I/O/CMOS
D[7]/SDO	8th bit of parallel data (MSB) or serial data output	100 kΩ internal pull-up	I/O/CMOS
DOTXP[1:0]	Positive differential output of 2 <sup>23</sup> -1 PRBS signal generator	50Ω internal pull-up to AV <sub>DD</sub> _IO	Output/PCML
DOTXN[1:0]	Negative differential output of 2 <sup>23</sup> -1 PRBS signal generator	50Ω internal pull-up to AV <sub>DD</sub> _IO	Output/PCML
CLKTXP[1:0]	Positive differential clock for 2 <sup>23</sup> -1 PRBS signal generator	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
CLKTXN[1:0]	Negative differential clock for 2 <sup>23</sup> -1 PRBS signal generator	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
CLKTXREF[1:0]	Low speed reference clock for 2 <sup>23</sup> -1 PRBS signal generator	(2, 3)	Input/CMOS
RXREFCLK	19.44 MHz clock reference for LOS detection	(2, 3)	Input/CMOS
XENTX[1:0]	Enable (active low) 2 <sup>23</sup> -1 PRBS signal generator clock	100 kΩ internal pull-up to AV <sub>DD</sub> _IO	Input/CMOS
DIRXP[1:0]	Positive differential data for 2 <sup>23</sup> -1 PRBS signal receiver	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
DIRXN[1:0]	Negative differential data for 2 <sup>23</sup> -1 PRBS signal receiver	50Ω internal pull-up to AV <sub>DD</sub> _IO	Input/PCML
XENRX[1:0]	Enable (active low) 2 <sup>23</sup> -1 pseudorandom RX clock/data	100 kΩ internal pull-up to AV <sub>DD</sub> _IO	Input/CMOS



**Table 2-7. High-Speed Signal Pins (2 of 2)**

Pin Name	Function	Termination	Type
XRSTRX[1:0]	Reset (active low) $2^{23}-1$ pseudorandom RX clock/data	100 k $\Omega$ internal pull-up to AV <sub>DD_IO</sub>	Input/CMOS
PERROR[1:0]	PRBS receiver bit error flag: latches High on first error (cleared on PRBS reset)	100 k $\Omega$ internal pull-up	Output/CMOS

**NOTES:**

1. In PRBS mode a portion of the PRBS signal will egress from the input terminal to which the PRBS transmitter is connected. The device normally connected to these terminals might need to be powered down or temporarily disconnected during PRBS operation; alternatively, any unused input can be used to route the PRBS signal to any output.
2. 100 k $\Omega$  internal pull-ups on all CMOS inputs, unless noted as pull-downs.
3. RXREFCLK and CLKTXREF[1:0] are CMOS inputs that are referenced to AV<sub>DD\_IO</sub>.

**Table 2-8. Control, Interface, and Alarm Pins**

Pin Name	Function	Termination	Type
R/XW	Parallel I/O: H = read, L = write	(1)	Input/CMOS
XDS/SCLK	Parallel I/O: data latch, serial I/O: serial clock (hysteresis)	(1)	Input/CMOS
XCS	Serial/parallel: active low I/O enable	(1)	Input/CMOS
SER/XPAR	Serial/parallel I/O select: H = serial, L = parallel	(1)	Input/CMOS
XRST	Hardware reset (active low)	(1)	Input/CMOS
XTEST	Mindspeed test terminal (active low)	(1)	Input/CMOS
XSET	Hardware xSet terminal enables switching multiple channel configurations simultaneously (active low)	(1)	Input/CMOS
MDSPDTEST[33:1]	Pins reserved for production test (should be left open)	(1)	N/C
TRIG[1:0]	CLKTX/16 for use as trigger	50 $\Omega$ internal pull-up to AV <sub>DD_IO</sub>	Output/PCML
LOS	Global loss of signal status	(1)	Output/CMOS

**NOTE:**

1. 100 k $\Omega$  internal pull-ups on all CMOS inputs, unless noted as pull-downs.



# 3.0 Control Registers Map and Descriptions

**Table 3-1. Control Registers Map (1 of 2)**

Addr	Register Name	d7	d6	d5	d4	d3	d2	d1	d0: LSB
<b>Common Registers</b>									
00	INCHSEL#0	InChSel[7]	InChSel[6]	InChSel[5]	InChSel[4]	InChSel[3]	InChSel[2]	InChSel[1]	InChSel[0]
01	INCHSEL#1	InChSel[7]	InChSel[6]	InChSel[5]	InChSel[4]	InChSel[3]	InChSel[2]	InChSel[1]	InChSel[0]
02	INCHSEL#2	InChSel[7]	InChSel[6]	InChSel[5]	InChSel[4]	InChSel[3]	InChSel[2]	InChSel[1]	InChSel[0]
⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
8Fh	INCHSEL#143	InChSel[7]	InChSel[6]	InChSel[5]	InChSel[4]	InChSel[3]	InChSel[2]	InChSel[1]	InChSel[0]
100	CHANCFG#0	offset	eq[1]	eq[0]	en_pe	out_level[1]	out_level[0]	in_mode[1]	in_mode[0]
101	CHANCFG#1	offset	eq[1]	eq[0]	en_pe	out_level[1]	out_level[0]	in_mode[1]	in_mode[0]
102	CHANCFG#2	offset	eq[1]	eq[0]	en_pe	out_level[1]	out_level[0]	in_mode[1]	in_mode[0]
⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
18Fh	CHANCFG#143	offset	eq[1]	eq[0]	en_pe	out_level[1]	out_level[0]	in_mode[1]	in_mode[0]
200	IN_CHAN_CTRL#0	0	0	0	0	inh_en	0	los_en	0
201	IN_CHAN_CTRL#1	0	0	0	0	inh_en	0	los_en	0
⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
28Fh	IN_CHAN_CTRL#143	0	0	0	0	inh_en	0	los_en	0
300	LOS_DR_SEL#0	0	dr_range	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
301	LOS_DR_SEL#1	0	dr_range	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
38Fh	LOS_DR_SEL#143	0	dr_range	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
<b>Even PRBS Registers</b>									
A0	PRBSRXCTRL_EVEN	en_patrx	0	rxmux	rst_rx	en_rx	core2rx	rxcdr_pd	0
A1	PRBSRXCHSEL_EVEN	rxchsel[7]	rxchsel[6]	rxchsel[5]	rxchsel[4]	rxchsel[3]	rxchsel[2]	rxchsel[1]	rxchsel[0]
A2	PRBSERROR_EVEN	rxerr[7]	rxerr[6]	rxerr[5]	rxerr[4]	rxerr[3]	rxerr[2]	rxerr[1]	rxerr[0]
A3	PRBSRX_DLY_EVEN	0	0	0	prbsrx_dly[4]	prbsrx_dly[3]	prbsrx_dly[2]	prbsrx_dly[1]	prbsrx_dly[0]
A4	RXCDR_CTRLA_EVEN	lolwinctrl[1]	lolwinctrl[0]	0	0	0	1	los_en	1
A5	RXCDR_CTRLB_EVEN	softreset	reserved	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
A6	RXCDR_ALARMS_EVEN	reserved	reserved	reserved	reserved	reserved	reserved	los	lol
A7	PRBSTXCTRL1_EVEN	0	txmux[1]	txmux[0]	rst_tx	en_tx	tx2core	pll_pd	0
A8	PRBSTXCTRL2_EVEN	0	0	pe_amp	en_pe	pe_dur	sel_div2pat	en_patrx	pwr_trig
A9	PRBSTXCHSEL_EVEN	txchsel[7]	txchsel[6]	txchsel[5]	txchsel[4]	txchsel[3]	txchsel[2]	txchsel[1]	txchsel[0]
AA	PLL_CTRLA_EVEN	lolwinctrl[1]	lolwinctrl[0]	0	0	0	0	0	1
AB	PLL_CTRLB_EVEN	softreset	reserved	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
<b>Odd PRBS Registers</b>									
AC	PRBSRXCTRL_ODD	en_patrx	0	rxmux	rst_rx	en_rx	core2rx	rxcdr_pd	0
AD	PRBSRXCHSEL_ODD	rxchsel[7]	rxchsel[6]	rxchsel[5]	rxchsel[4]	rxchsel[3]	rxchsel[2]	rxchsel[1]	rxchsel[0]
AE	PRBSERROR_ODD	rxerr[7]	rxerr[6]	rxerr[5]	rxerr[4]	rxerr[3]	rxerr[2]	rxerr[1]	rxerr[0]
AF	PRBSRX_DLY_ODD	0	0	0	prbsrx_dly[4]	prbsrx_dly[3]	prbsrx_dly[2]	prbsrx_dly[1]	prbsrx_dly[0]
B0	RXCDR_CTRLA_ODD	lolwinctrl[1]	lolwinctrl[0]	0	0	0	1	los_en	1
B1	RXCDR_CTRLB_ODD	softreset	reserved	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]
B2	RXCDR_ALARMS_ODD	reserved	reserved	reserved	reserved	reserved	reserved	los	lol
B3	PRBSTXCTRL1_ODD	0	txmux[1]	txmux[0]	rst_tx	en_tx	tx2core	pll_pd	0
B4	PRBSTXCTRL2_ODD	0	0	pe_amp	en_pe	pe_dur	sel_div2pat	en_patrx	pwr_trig
B5	PRBSTXCHSEL_ODD	txchsel[7]	txchsel[6]	txchsel[5]	txchsel[4]	txchsel[3]	txchsel[2]	txchsel[1]	txchsel[0]
B6	PLL_CTRLA_ODD	lolwinctrl[1]	lolwinctrl[0]	0	0	0	0	0	1
B7	PLL_CTRLB_ODD	softreset	reserved	data_rate[5]	data_rate[4]	data_rate[3]	data_rate[2]	data_rate[1]	data_rate[0]

**Table 3-1. Control Registers Map (2 of 2)**

Addr	Register Name	d7	d6	d5	d4	d3	d2	d1	d0: LSB
<b>Local Registers</b>									
B8	XSETMODE	0	0	0	0	0	0	xset[1]	xset[0]
B9	XSETCMD	xsetcmd[7]	xsetcmd[6]	xsetcmd[5]	xsetcmd[4]	xsetcmd[3]	xsetcmd[2]	xsetcmd[1]	xsetcmd[0]
BA	IOENABLE	offset	eq[1]	eq[0]	en_individ	out_level[1]	out_level[0]	in_mode[1]	in_mode[0]
BB	CORECTRL	0	0	0	pe_amp	pe_dur	en_pe	1	en_smartpwr
BF	SOFTRESET	srst[7]	srst[6]	srst[5]	srst[4]	srst[3]	srst[2]	srst[1]	srst[0]
C0	CHIPREV	rev[7]	rev[6]	rev[5]	rev[4]	rev[3]	rev[2]	rev[1]	rev[0]
C1	PRODCODE	prod[7]	prod[6]	prod[5]	prod[4]	prod[3]	prod[2]	prod[1]	prod[0]
C3	WIN_INLCK_LOL	win_inlck[7]	win_inlck[6]	win_inlck[5]	win_inlck[4]	win_inlck[3]	win_inlck[2]	win_inlck[1]	win_inlck[0]
C4	WIN_OUTLCK_LOL	win_outlck[7]	win_outlck[6]	win_outlck[5]	win_outlck[4]	win_outlck[3]	win_outlck[2]	win_outlck[1]	win_outlck[0]
CB	GLOBAL_CTRL	0	0	0	0	0	1	0	clear_alarm
1A2	LOS_STATn	los_stat[7]	los_stat[6]	los_stat[5]	los_stat[4]	los_stat[3]	los_stat[2]	los_stat[1]	los_stat[0]
1A3	LOS_STATN	los_stat[7]	los_stat[6]	los_stat[5]	los_stat[4]	los_stat[3]	los_stat[2]	los_stat[1]	los_stat[0]
⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1B3	LOS_STATN	los_stat[7]	los_stat[6]	los_stat[5]	los_stat[4]	los_stat[3]	los_stat[2]	los_stat[1]	los_stat[0]
<b>NOTES:</b>									
D[7]... D[0] represent the internal bus, which is mapped to the data in both the serial and parallel mode.									
Blank register bits are undefined for a write and read.									

### 3.1 Control Registers Descriptions

**Table 3-2. Input Channel Selection (INCHSEL: Address 00h–47h/00h–8Fh)  
(Output channel = address Input to route to output = data)**

Bits	Type	Default	Label	Description
7:0	R/W	00h	INCHSEL	Select input channel (data) to route to selected output (address). In#0 = 00h, In#1 = 01h, ...In#143 = 8Fh.

**Table 3-3. I/O Input/Output Configuration (CHANCFG: Address 100h–147h/100h–18Fh)  
(Selected channel + 100h is the address)**

Bits	Type	Default	Label	Description
7	R/W	0	DC offset	Input DC offset 0: DC offset enable (default) 1: DC offset disable
6:5	R/W	01	eq	Input equalization 00: Minimum EQ (≈ 9 dB) 01: Small EQ (≈ 12 dB) (default) 10: Medium EQ (≈ 15 dB) 11: Large EQ (≈ 18 dB)
4	R/W	0	en_pe	Enable de-emphasis— <i>en_individ</i> (BAh, bit 4) must be set to 1 for this bit to be functional. 0: Disabled. 1: Enabled.
3:2	R/W	11	out_level	<i>en_individ</i> (BAh, bit 4) must be set to 1 for these bits to be functional. 00: 500 mVp–p differential output. 01: 900 mVp–p differential output. 10: 1200 mVp–p differential output. 11: Disable output.
1:0	R/W	10	in_mode	<i>en_individ</i> (BAh, bit 4) must be set to 1 for these bits to be functional. 00: Reserved. 01: Reserved. 10: Input channel is powered down. 11: Input channel is active.

**Table 3-4. Input Channel Control (IN\_CHAN\_CTRL: Address 200h–247h/200h–28Fh)**

Bits	Type	Default	Label	Description
7:4	R/W	0000	—	Reserved, set to 0.
3	R/W	0	inh_en	0: Inhibit disabled. 1: Inhibit enabled.
2	R/W	1	—	Reserved, defaults to 1 but must be set to 0.
1	R/W	1	los_en	0: LOS disabled. 1: LOS enabled (default).
0	R/W	1	—	Reserved, defaults to 1 but must be set to 0.

**Table 3-5. Individual Channel LOS Data Rate Control (Select Channel 300h-347h/300h-38Fh)**

Bits	Type	Default	Label	Description
7	R/W	0	LOS_dr_sel	Reserved, default to 0.
6	R/W	0	dr_range	0: 2–3.2 Gbps operation (default). 1: 1–1.6 Gbps operation.
5:0	R/W	011010	—	Select data rate. See <a href="#">Section 4.3.9.1</a> for data rate programming. 011010: 2.488 Gbps (default).

### 3.1.1 Even PRBS Registers

**Table 3-6. PRBS RX Control (Even) (PRBSRXCTRL\_EVEN: Address A0h)**

Bits	Type	Default	Label	Description
7	R/W	0	en_patrx	0: PRBSRX configured for $2^{23}-1$ PRBS pattern. 1: PRBSRX configured for simple “1010” or “1100” pattern.
6	R/W			Reserved, must be set to 0.
5	R/W	1	rxmux	Select RX data input. 0: Select input form cross point core. 1: Select input from terminals DIRXP/N.
4	R/W	1	rst_rx	Reset RX PRBS receiver. 0: RX PRBS receiver enabled. 1: RX PRBS in reset.
3	R/W	0	en_rx	0: RX PRBS disabled. 1: RX PRBS enabled.
2	R/W	0	core2rx	0: Disconnect all cross point outputs from PRBS RX. 1: Route cross point outputs to PRBS receiver.
1	R/W	1	rxcdr_pd	PRBS receiver CDR control. 0: CDR is enabled. 1: CDR is disabled.
0	R/W	—	—	Reserved, must be set to 0.

**Table 3-7. PRBS RX Channel Select (even) (PRBSRXCHSEL\_EVEN: Address A1h)**

Bits	Type	Default	Label	Description
7:0	R/W	00h	rxchSel	Selects channel for PRBS RX.

**Table 3-8. PRBS RX Error Count (Read Only) (PRBSERROR\_EVEN: Address A2h)**

Bits	Type	Default	Label	Description
7:0	RO	—	rxerr	PRBS RX error count register (read-only). Although this is a read-only register, a write of any value must be performed to latch the latest error count. A PRBS RX reset (address A0h, bit 4) will clear the PRBS RX error count register.

**Table 3-9. PRBS RX Delay Select (even) (PRBSRX\_DLY\_EVEN: Address A3h)**

Bits	Type	Default	Label	Description
7:5	R/W	—	—	Reserved, must be set to 0
4:0	R/W	00101	prbsrx_dly	PRBS RX delay select in increments of 1/32 of a bit time (12.5 ps for 2.488 GHz operation). 00000: No Delay. 00001: 1/32 of a bit time (12.5 ps for 2.488 GHz operation). ... 00101: 5/32 of a bit time (62.5 ps for 2.488 GHz operation) (default). ... 11111: One bit time (400 ps for 2.488 GHz operation).

**Table 3-10. PRBS RX CDR Control A (even) (RXCDR\_CTRLA\_EVEN: Address A4h)**

Bits	Type	Default	Label	Description
7:6	R/W	00	lolwinctrl	00: LOL window settings are taken from global register. 01: LOL window settings are fixed to 48h (narrow) and 55h (wide). 10: LOL window settings are fixed to 91h (narrow) and AAh (wide) (recommended settings). 11: Content of register RXCDR_CTRLB is stored into a separate register, which programs the offset of the VCO counter start value.
5:4	R/W	—	—	Reserved, must be set to 0.
3	R/W	1	—	0: Autoinhibit disabled. 1: Autoinhibit enabled.
2	R/W	—	—	Reserved, must be set to 1.
1	R/W	1	los_en	0: LOS circuit disabled. 1: LOS enabled.
0	R/W	—	—	Reserved, must be set to 1.

**Table 3-11. PRBS RX CDR Control B (even) (RXCDR\_CTRLB\_EVEN: Address A5h)**

Bits	Type	Default	Label	Description
7	R/W	0	softreset	0: CDR is in normal mode. 1: CDR is in reset.
6	R/W	0	MSPD	Reserved, defaults to “0”, must be set to “1” to use PRBS RX CDR.
5:0	R/W	011010	data_rate	Select data rate. Please refer to <a href="#">Table 4-6</a> in the PRBS CDR Control Parameters section for data rate programming. 011010: Reference frequency multiplied by 128d.

**Table 3-12. PRBS RX Alarms (Read Only) (even) (RXCDR\_ALARMS\_EVEN: Address A6h)  
(Cleared on write, a high alarm status gets latched into the register)**

Bits	Type	Default	Label	Description
7:2	RO	—	—	Reserved.
1	RO	—	los	Loss of Signal alarm.
0	RO	—	lol	Loss of Lock alarm.

**Table 3-13. PRBS TX Control 1 (even) (PRBSTXCTRL1\_EVEN: Address A7h)**

Bits	Type	Default	Label	Description
7	R/W	—	—	Reserved, must be set to 0.
6:5	R/W	10	txmux	Select PRBS TX clock input. 00: Select clock generated by PRBS TX PLL. 01: Select clock recovered from PRBS RX CDR. 10: Select clock from input pins CLKTXP/N. 11: None.
4	R/W	1	rst_tx	0: PRBS TX pattern generator in normal operation. 1: Reset PRBS TX pattern generator.
3	R/W	0	en_tx	0: TX PRBS disabled. 1: TX PRBS enabled.
2	R/W	0	tx2core	0: Disable the PRBS TX from going to the inputs. 1: Route PRBS TX pattern through cross point.
1	R/W	1	pll_pd	PRBS TX PLL control. 0: TX PLL enabled. 1: TX PLL disabled.
0	R/W	—	—	Reserved, must be set to 0.

**Table 3-14. PRBS TX Control 2 (even) (PRBSTXCTRL2\_EVEN: Address A8h)**

Bits	Type	Default	Label	Description
7:6	R/W	—	—	Reserved, must be set to 0.
5	R/W	0	pe_amp	Control of de-emphasis amplitude. 0: 50% DE. 1: 67% DE.
4	R/W	0	en_pe	Enable de-emphasis. 0: Disable. 1: Enable.
3	R/W	1	pe_dur	Control of de-emphasis duration. 0: Approximately 1200 ps. 1: Approximately 600 ps.
2	R/W	0	sel_div2_pat	Select TX pattern. <i>en_pattx</i> has to be high for this bit to be functional. 0: Select 1010 pattern. 1: Select 1100 pattern.
1	R/W	0	en_pattx	Select TX PRBS or simple pattern. 0: Select PRBS TX pattern. 1: Select simple pattern: 1010 or 1100 determined by <i>sel_div2_pat</i> .
0	R/W	0	pwr_trig	0: TX PRBS trigger disabled. 1: TX PRBS trigger enabled.

**Table 3-15. PRBS TX Channel Select (even) (PRBSTXCHSEL\_EVEN: Address A9h)**

Bits	Type	Default	Label	Description
7:0	R/W	01h	txchSel	Select channel for PRBS TX.

**Table 3-16. PRBS TX PLL Control A (even) (PLL\_CTRLA\_EVEN: Address AAh)**

Bits	Type	Default	Label	Description
7:6	R/W	00	lolwinctrl	00: LOL window settings are taken from global register. 01: LOL window settings are fixed to 48h (narrow) and 55h (wide). 10: LOL window settings are fixed to 91h (narrow) and AAh (wide) (recommended setting). 11: Content of register PLL_CTRLB is stored into a separate register, which programs the offset of the VCO counter start value.
5:1	R/W	—	—	Reserved, must be set to 0.
0	R/W	—	—	Reserved, must be set to 1.



**Table 3-17. PRBS TX PLL Control B (even) (PLL\_CTRLB\_EVEN: Address ABh)**

Bits	Type	Default	Label	Description
7	R/W	0	softreset	0: PLL is in normal mode. 1: PLL is in reset.
6	R/W	0	MSPD	Reserved, defaults to “0”, must be set to “1” to use PRBS Tx PLL.
5:0	R/W	011010	data_rate	Select data rate. Please refer to <a href="#">Table 4-6</a> in the PRBS CDR Control Parameters section for data rate programming. 011010: Reference frequency multiplied by 128d.

### 3.1.2 Odd PRBS Registers

**Table 3-18. PRBS RX Control (Odd) (PRBSRXCTRL\_ODD: Address ACh)**

Bits	Type	Default	Label	Description
7	R/W	0	en_patrx	0: PRBSRX configured for $2^{23}-1$ PRBS pattern. 1: PRBSRX configured for simple “1010” or “1100” pattern.
6	R/W			Reserved, must be set to 0.
5	R/W	1	rxmux	Select RX data input. 0: Select input from cross point core. 1: Select input from terminals DiRxP/N.
4	R/W	1	rst_rx	Reset RX PRBS receiver. 0: RX PRBS receiver enabled. 1: RX PRBS in reset.
3	R/W	0	en_rx	0: RX PRBS disabled. 1: RX PRBS enabled.
2	R/W	0	core2rx	0: Disconnect all cross point outputs from PRBS RX. 1: Route cross point outputs to PRBS receiver.
1	R/W	1	rxcdr_pd	PRBS receiver CDR control. 0: CDR is enabled. 1: CDR is disabled.
0	R/W	—	—	Reserved, must be set to 0.

**Table 3-19. PRBS RX Channel Select (odd) (PRBSRXCHSEL\_ODD: Address ADh)**

Bits	Type	Default	Label	Description
7:0	R/W	01h	rxchSel	Selects channel for PRBS RX.

**Table 3-20. PRBS RX Error Count (Read Only) (odd) (PRBSERROR\_ODD: Address AEh)**

Bits	Type	Default	Label	Description
7:0	RO	—	rxerr	PRBS RX error count register (read-only). Although this is a read-only register, a write of any value must be performed to latch the latest error count. A PRBS RX reset (address A0h, bit 4) will clear the PRBS RX error count register.

**Table 3-21. PRBS RX Delay Select (odd) (PRBSRX\_DLY\_ODD: Address AFh)**

Bits	Type	Default	Label	Description
7:5	R/W			Reserved, must be set to 0.
4:0	R/W	00101	prbsrx_dly	PRBS RX delay select in increments of 1/32 of a bit time (12.5 ps for 2.488 GHz operation). 00000: No Delay. 00001: 1/32 of a bit time (12.5 ps for 2.488 GHz operation). ... 00101: 5/32 of a bit time (62.5 ps for 2.488 GHz operation). ... 11111: One bit time (400 ps for 2.488 GHz operation).

**Table 3-22. PRBS RX CDR Control A (odd) (RXCDR\_CTRLA\_EVEN: Address B0h)**

Bits	Type	Default	Label	Description
7:6	R/W	00	lolwinctrl	00: LOL window settings are taken from global register. 01: LOL window settings are fixed to 48h (narrow) and 55h (wide). 10: LOL window settings are fixed to 91h (narrow) and AAh (wide) (recommended setting). 11: Content of register RXCDR_CTRLB is stored into a separate register, which programs the offset of the VCO counter start value.
5:4	R/W	—	—	Reserved, must be set to 0.
3	R/W	1	—	0: Autoinhibit disabled. 1: Autoinhibit enabled.
2	R/W	—	—	Reserved, must be set to 1.
1	R/W	1	los_en	0: LOS circuit disabled. 1: LOS enabled.
0	R/W	—	—	Reserved, must be set to 1.

**Table 3-23. PRBS RX CDR Control B (odd) (RXCDR\_CTRLB\_ODD: Address B1h)**

Bits	Type	Default	Label	Description
7	R/W	0	softreset	0: CDR is in normal mode. 1: CDR is in reset.
6	R/W	0	MSPD	Reserved, defaults to “0”, must be set to “1” to use PRBS RX CDR.
5:0	R/W	011010	data_rate	Select data rate. Please refer to <a href="#">Table 4-6</a> in the PRBS CDR Control Parameters section for data rate programming. 011010: Reference frequency multiplied by 128d.

**Table 3-24. PRBS RX Alarms (Read Only) (odd) (RXCDR\_ALARMS\_ODD: Address B2h)**

Bits	Type	Default	Label	Description
7:2	RO	—	—	Reserved.
1	RO	—	los	Loss of Signal alarm.
0	RO	—	lol	Loss of Lock alarm.

**Table 3-25. PRBS TX Control 1 (odd) (PRBSTX\_ctrl1\_odd: Address B3h)**

Bits	Type	Default	Label	Description
7	R/W	—	—	Reserved, must be set to 0.
6:5	R/W	10	txmux	Select PRBS TX clock input. 00: Select clock generated by PRBS TX PLL. 01: Select clock recovered from PRBS RX CDR. 10: Select clock from input terminals CLKTXP/N. 11: None.
4	R/W	1	rst_tx	0: PRBS TX pattern generator in normal operation. 1: Reset PRBS TX pattern generator.
3	R/W	0	en_tx	0: TX PRBS disabled. 1: TX PRBS enabled.
2	R/W	0	tx2core	0: Disable the PRBS TX from going to the inputs. 1: Route PRBS TX pattern through cross point.
1	R/W	1	pll_pd	PRBS TX PLL control. 0: TX PLL is enabled. 1: TX PLL is disabled.
0	R/W	—	—	Reserved, must be set to 0.

**Table 3-26. PRBS TX Control 2 (odd) (PRBSTX\_ctrl2\_odd: Address B4h)**

Bits	Type	Default	Label	Description
7:6	R/W	—	—	Reserved, must be set to 0.
5	R/W	0	pe_amp	Control of de-emphasis amplitude. 0: 50% PE. 1: 67% PE.
4	R/W	0	en_pe	Enable de-emphasis. 0: Disable. 1: Enable.
3	R/W	1	pe_dur	Control of de-emphasis duration. 0: Approximately 1200 ps. 1: Approximately 600 ps.
2	R/W	0	sel_div2_pat	Select TX pattern. <i>en_pattx</i> has to be high for this bit to be functional. 0: Select 1010 pattern. 1: Select 1100 pattern.
1	R/W	0	en_pattx	Select TX PRBS or simple pattern. 0: Select PRBS TX pattern. 1: Select simple pattern: 1010 or 1100 determined by <i>sel_div2_pat</i> .
0	R/W	0	pwr_trig	0: TX PRBS trigger disabled. 1: TX PRBS trigger enabled.

**Table 3-27. PRBS TX Channel Select (odd) (PRBSTXCHSEL\_ODD: Address B5h)**

Bits	Type	Default	Label	Description
7:0	R/W	01h	txchSel	Selects channel for PRBS TX.

**Table 3-28. PRBS TX PLL Control A (odd) (PLL\_CTRLA\_ODD: Address B6h)**

Bits	Type	Default	Label	Description
7:6	R/W	00	lolwinctrl	00: LOL window settings are taken from global register. 01: LOL window settings are fixed to 48h (narrow) and 55h (wide). 10: LOL window settings are fixed to 91h (narrow) and AAh (wide) (recommended setting). 11: Content of register PLL_ctrlB is stored into a separate register, which programs the offset of the VCO counter start value.
5:1	R/W	—	—	Reserved, must be set to 0.
0	R/W	—	—	Reserved, must be set to 1.

**Table 3-29. PRBS TX PLL Control B (odd) (PLL\_CTRLB\_ODD: Address B7h)**

Bits	Type	Default	Label	Description
7	R/W	0	softreset	0: CDR is in normal mode. 1: CDR is in reset.
6	R/W	0	MSPD	Reserved, defaults to “0”, must be set to “1” to use PRBS TX PLL.
5:0	R/W	011010	data_rate	Select data rate. Please refer to <a href="#">Table 4-6</a> in the PRBS CDR Control Parameters section for data rate programming. 011010: Reference frequency multiplied by 128d.

### 3.1.3 Global Registers

**Table 3-30. XSET MODE (xSET mode: Address B8h)**

Bits	Type	Default	Label	Description
7:2	R/W	—	—	Reserved, must be set to 0.
1:0	R/W	00	xset	Selects the XSET mode. 00: ACL latches are transparent. Any switch setting written immediately affects the core configuration. 01: ACL latches are controlled through register B9h (software XSET). 10: ACL latches are controlled by terminal <b>XSET</b> (hardware control). 11: N/A.

**Table 3-31. Software xSET (Read back always 00h) (xSET cmd: Address B9h)**

Bits	Type	Default	Label	Description
7:0	R/W	—	xsetcmd	Register B8h (XSET mode) needs to be set to 01 in order for this register to be functional. Any value written to this register will update the ACL with the ICL.

**Table 3-32. I/O Enable (IOENABLE: Address BAh)**

Bits	Type	Default	Label	Description
7	R/W	0	DC offset	Input DC offset 0: DC offset enable (default) 1: DC offset disable
6:5	R/W	01	EQ	Input equalization 00: Minimum EQ (≈ 9 dB) 01: Small EQ (≈ 12 dB) (default) 10: Medium EQ (≈ 15 dB) 11: Large EQ (≈ 18 dB)
4	R/W	0	en_individ	This bit controls individual IO control. 0: Individual input/output configuration (100 to 147h/100h to 18Fh) is bypassed. 1: Input/outputs are individually controlled by registers 100 to 147h/100h to 18Fh.
3:2	R/W	11	out_level	<i>en_individ</i> (BAh, bit 4) must be set to 0 for these bits to be functional. 00: 500 mVp-p differential on all outputs. 01: 900 mVp-p differential on all outputs. 10: 1200 mVp-p differential on all outputs. 11: Disable all outputs.
1:0	R/W	10	in_mode	<i>en_individ</i> (BAh, bit 4) must be set to 0 for these bits to be functional. 00: Reserved. 01: Reserved. 10: All input channels are powered down. 11: All input channels are active.

**Table 3-33. Core Control (CORECTRL: Address BBh)**

Bits	Type	Default	Label	Description
7:5	R/W	—	—	Reserved, must be set to 0.
4	R/W	0	pe_amp	Global control of de-emphasis amplitude. 0: 50% PE. 1: 67% PE.
3	R/W	1	pe_dur	Global control of de-emphasis duration. 0: Approximately 1200 ps. 1: Approximately 600 ps (default).
2	R/W	0	en_pe	<i>en_individ</i> (BAh, bit 4) must be set to 0 for this bit to be functional. 0: Disable de-emphasis for all outputs. 1: Enable de-emphasis for all outputs.
1	R/W	—	—	Reserved, must be set to 1.
0	R/W	1	en_smartpwr	Core SmartPower™ control. 0: Core fully powered. 1: Core in low power mode.

**Table 3-34. Software Reset (SOFTRESET: Address BFh)**

Bits	Type	Default	Label	Description
7:0	R/W	00h	srst	Software reset: Needs two consecutive Writes with DATA = AAh. If second Write is not a reset, register is cleared. Third Write required to bring out of reset.

**Table 3-35. Chip Revision (CHIPREV: Address C0h)**

Bits	Type	Default	Label	Description
7:0	RO	—	rev	Chip Revision Number: M21131-13/M21131G-13: 05h M21131-23/M21131G-23: 05h M21151-14/M21151G-14: 05h M21151-23/M21151G-23: 05h

**Table 3-36. Product Code (PRODCODE: Address C1h)**

Bits	Type	Default	Label	Description
7:0	RO	—	prod	Product Code Number M21131 = 40h M21151 = C0h

**Table 3-37. Global LOL Window Detector Inlock Value (WIN\_INLCK\_LOL: Address C3h)**

Bits	Type	Default	Label	Description
7:0	R/W	1Eh	win_inlck	Sets the in lock window value.

**Table 3-38. Global LOL Window Detector Outlock Value (WIN\_OUTLCK\_LOL: Address C4h)**

Bits	Type	Default	Label	Description
7:0	R/W	03	win_outlck	Sets the out lock window value.

**Table 3-39. Global Control (GLOBAL\_CTRL: Address CBh)**

Bits	Type	Default	Label	Description
7:3	R/W	—	—	Reserved, must be set to 0.
2	R/W	—	—	Reserved, must be set to 1.
1	R/W	—	—	Reserved, must be set to 0.
0	R/W	0	clear_alarms	0: All input and PRBS LOS alarms are active. 1: Clear all PRBS and input LOS alarms.

**Table 3-40. LOS Alarms Register Bank 1 to 18 (LOS\_STATn: 1A2–1B3h)**

Bits	Type	Default	Label	Description
7:0	RO	—	los_stat	(Read only, cleared by clear_alarms). 0: LOS alarm on CDR (n*8+[!]) is not present. 1: LOS alarm on CDR (n*8+[!]) is present.





## 4.0 Functional Description

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### 4.1 Overview

The M21131/M21151, designed for today's demanding telecom and datacom applications, is a low-power CMOS, high-speed 72x72/144x144 crosspoint switch with input equalization, output de-emphasis, and built-in system test features.

The SmartPower™ features offer dynamically scalable switch settings to further reduce power consumption without affecting the operation of the remaining channels.

To improve signal quality each input buffer is preceded by a programmable input equalizer (IE) and each output includes output de-emphasis (PE). The IE removes ISI jitter which is usually caused by PCB skin effect losses. The IE circuit opens the input data eye in applications where long PCB traces and cables are used. The PE provides a boost of the high frequency content of the output signal, such that the data eye remains open after passing through a long interconnect of PCB traces and cables. There are two amplitude settings and two duration settings that can be selected on a global basis. De-emphasis can be enabled on a per-channel basis.

The device supports data rates from 0 to 3.2 Gbps on each channel, allowing any combination of SONET, Fibre Channel (1x and 2x), InfiniBand, Gigabit Ethernet and 10 Gbps Ethernet traffic.

The switch includes a pair of on-board  $2^{23}-1$  pseudo-random bit sequence transmitters (PRBS TX) and receivers (PRBS RX) for system verification purposes.

Three-stage switch fabrics with up to 2,880 x 2,880 ports, carrying over 10 Terabits per second of traffic, can be designed using this non-blocking switch, with multi-cast and broadcast abilities.

All inputs and outputs are differential PCML (positive current mode logic) with supply voltages ranging from 1.2V to 2.5V. The output levels are programmable at 500 mV, 900 mV, and 1200 mV.

The M21131/M21151 is available in a 1156 terminal, 35 mm, CBGA (Ceramic Ball Grid Array) package. The green 72x72/144x144 crosspoint switch is the M21131G/M21151G. The green devices share the same features, specifications, and pinout as the non-green devices.

Figure 4-1. Jitter Removal by Input Equalization and Output De-Emphasis at 3.2 Gbps

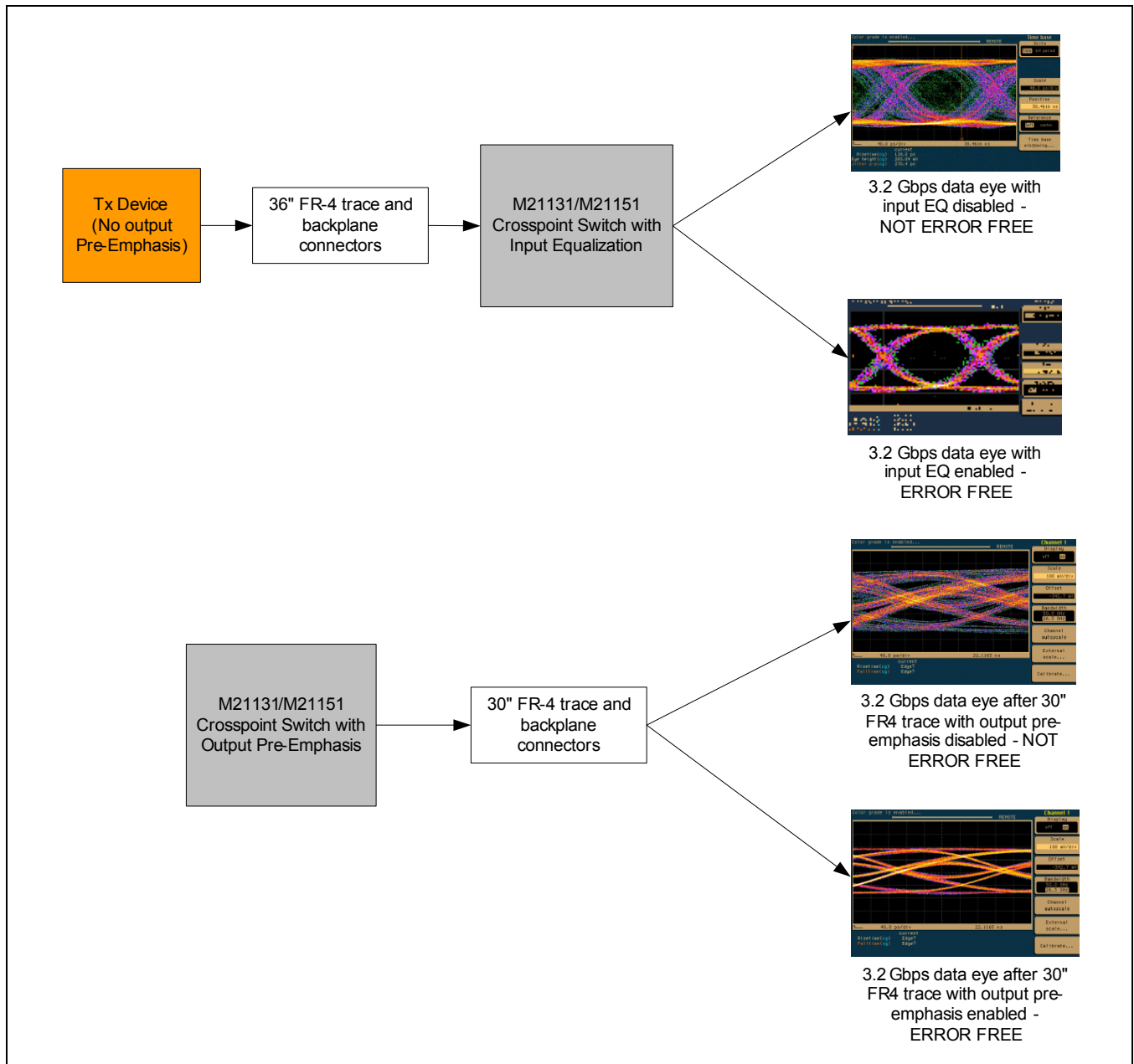


Figure 4-2. M21131/M21151 Functional Block Diagram

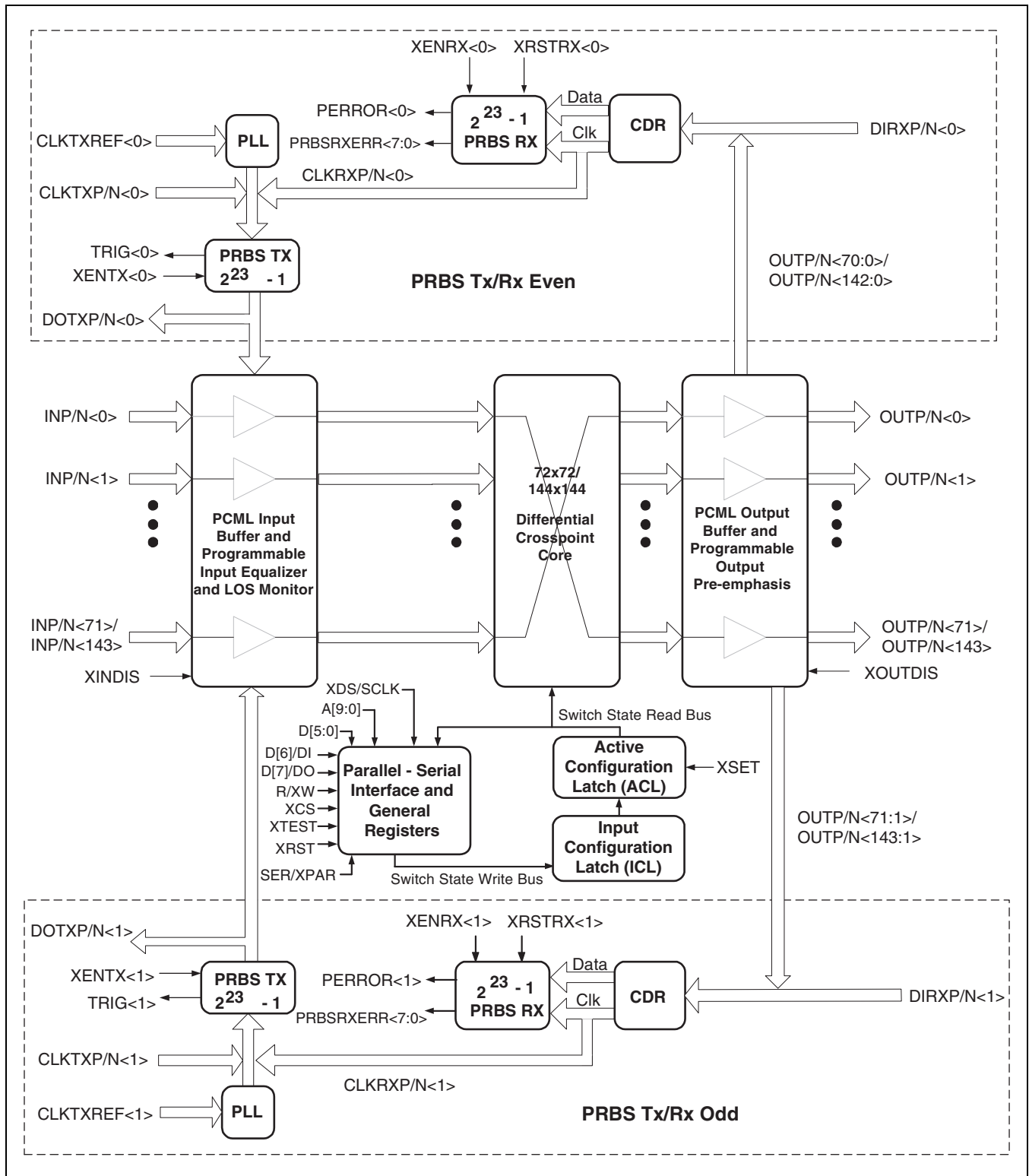


Figure 4-3. PCML Input and Output Equivalent Circuits

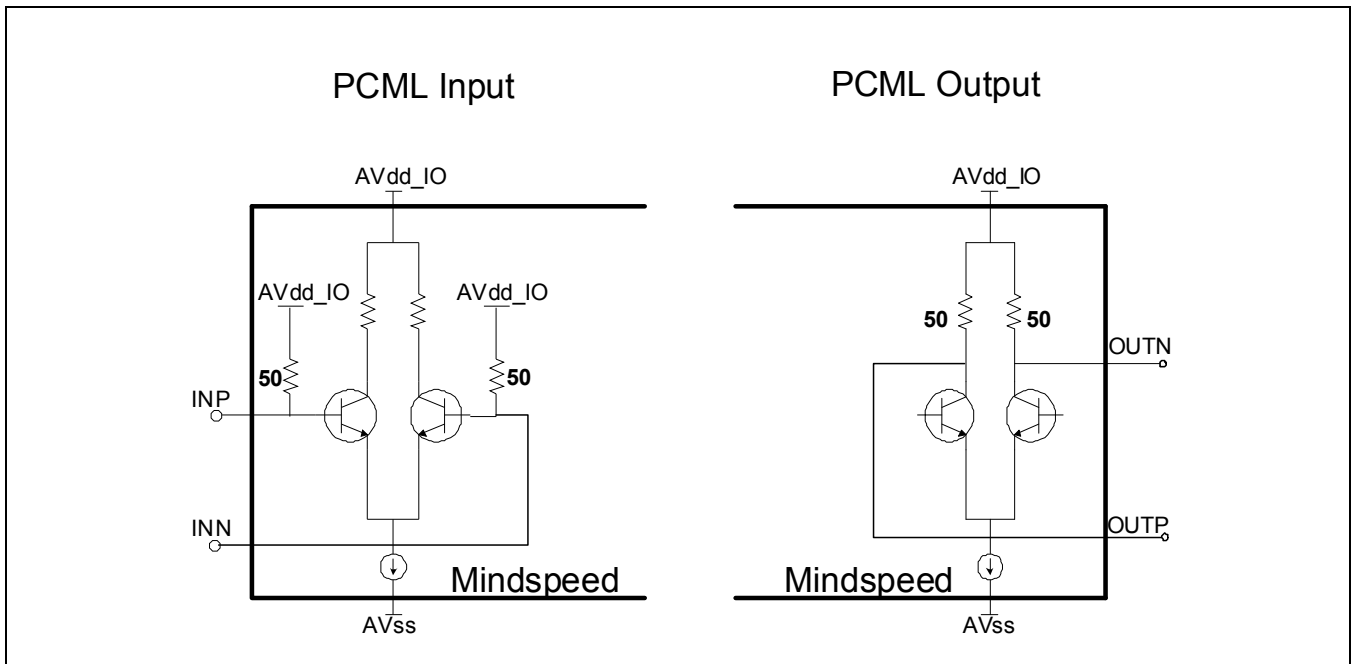
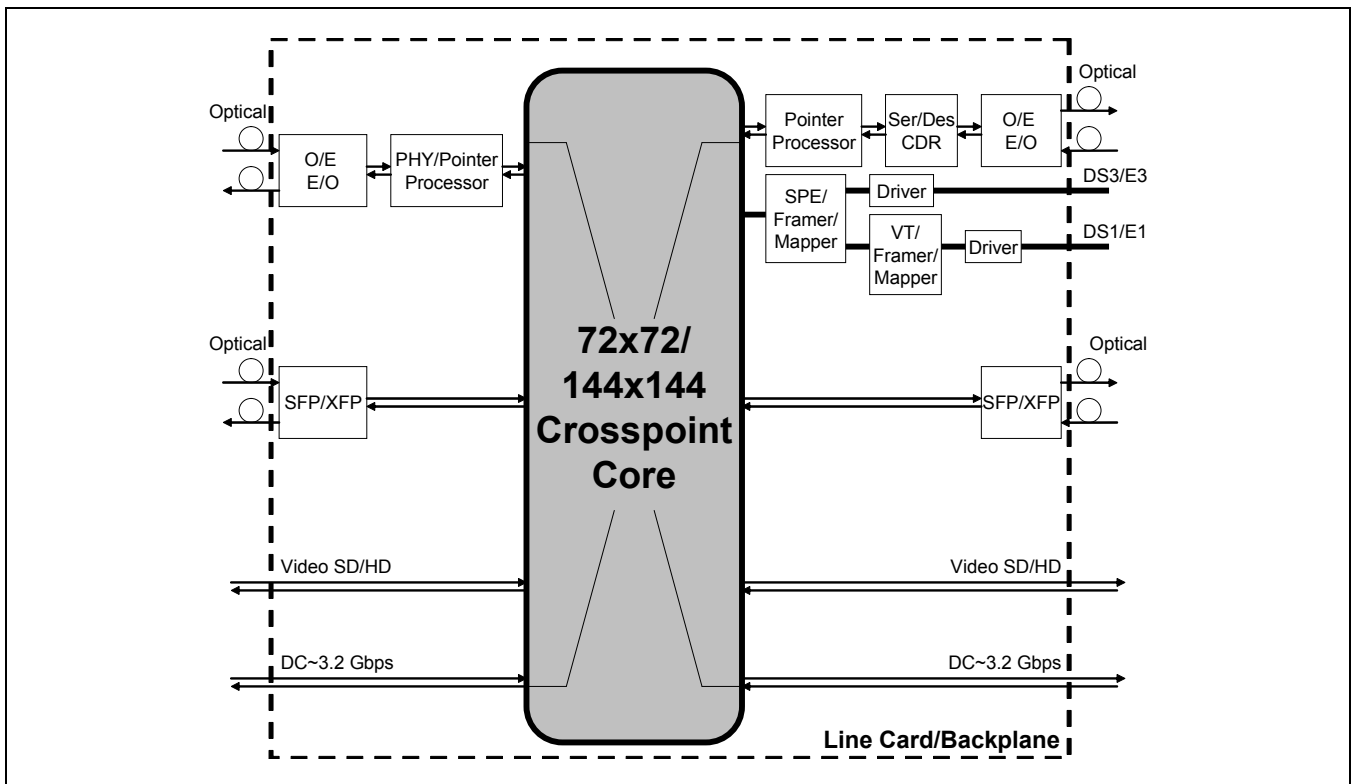


Figure 4-4. Crosspoint Application Example



## 4.2 Detailed Description

### 4.2.1 Document Conventions

This document uses the following text styling conventions:

Signal names and terminal numbers are listed in all upper case letters denoting each functional name part, with its related signal polarity indicated by a upper case 'N' or 'P'. Thus, data input signal names are indicated, for example as: 'DINP' and 'DINN'.

A signal name and an associated channel number (0 through 71/0 through 143) are indicated as DINP[n] and DINN[n] where 'n' is a channel number.

A register name is typed in all upper case preceded by the word register with each functional name part separated by an underscore, additionally, brackets group register bit numbers, and sub-function names are in initial caps such as for example only: 'register CONTROL\_FUNCTION[5:4] Los\_hyst'.

In order to distinguish terminal names from internally generated signals, the word 'terminal' is included in reference to an input, output, or control, such as: 'the signal on terminal ABC controls function x', or 'when the signal on terminal ABC = H function x is enabled'.

Terminal function descriptions generally do not repeat the word terminal.

### 4.2.2 Power Supply Configurations

Below is a summary of possible voltage configurations for the switch core and input/output buffers.

- 2.5V IO, 1.2V core
- 1.8V IO, 1.2V core
- 1.5V IO, 1.2V core
- 1.2V IO, 1.2V core (tied together externally)

The I/O supply voltage can be chosen independently, no register bit setting is required. The AV<sub>DD</sub>\_IO and AV<sub>DD</sub>\_CORE supplies are separate from the DV<sub>DD</sub>\_IO supply, and can be any combination of values specified in [Table 1-2](#).

## 4.3 Serial Interface and Switch Programming

The crosspoint switch uses +1.8V/+2.5V/+3.3V CMOS interface levels to program the switch state (SS). All input terminals have a 100 K $\Omega$  internal pull-up, except XINDIS and XOUTDIS, which have internal 100 K $\Omega$  pull-downs. The communication protocol may be either a serial synchronous interface or a parallel asynchronous interface using eight or ten bits. Either interface can:

- Program the switch state
- Individually enable/disable inputs or outputs
- Access control registers and auxiliary functions
- Read back the current state of the switch
- Control the programmable equalization

This section details the operation of the I/O interface and switch programming in [Section 4.3.4](#). The auxiliary functions and address mapping are described in the section, Switch Function Details.

### 4.3.1 Switch State Register Concept

The various switch functions are accessed through 8-bit registers (memory), which are addressed with the 10-bit address bus. The contents of the registers are transferred via an 8-bit data bus during a read or write.

The M21131/M21151 switch-state controller uses a double-buffered register. The active configuration latch (ACL) holds the actual switch setting while the input configuration latch (ICL) holds either the actual switch setting or the next switch setting, depending on the mode of operation.

The XSETMODE register selects one of three modes of operation:

- **Default Mode**—core configuration updated after every register write.

With XSETMODE = 00h, the first mode is enabled and is the default mode after a reset. Consequently, the state of the switch changes with each write to a register determining the switch state. In the write mode, as soon as the signal on terminal XDS makes a low-to-high transition, the input channel specified by data for the output selected by the 10-bit address bus passes directly through the double buffer memory (ICL/ACL). As soon as the desired data passes through the ACL, the crosspoint core routes the selected input to the desired output to physically change the switch state. On the rising edge of XDS, this channel is stored (latched) into both the ICL and ACL.

- **XSET Mode**—core configuration updated after hardware XSET command.

When register XSETMODE = 10b the hardware XSET mode is enabled. In this mode, the desired switch state (which may contain one or more routing changes) is written first to the ICL, but the switch state does not change since the data is blocked from the ACL. With either the hardware or software XSET command, the contents of the ICL are transferred to the ACL, which physically changes the switch state in the switching core. This mode allows 1 to 144 channels to change at the same time. On the falling edge of the XSET signal, the ICL contents are passed to the ACL and the switch state changes. On the rising edge of the XSET signal, the switch state is latched.

- **XSET Mode**—core configuration updated after software XSET command.

When register XSETMODE = 01b the software XSET mode is selected, and the desired switch routing is written into the appropriate registers to update the ICL without affecting the ACL. Then, a write of any value to the XSETCMD register will update the ACL with the current contents of the ICL, and the switch state changes. The interface is configured into the parallel mode by forcing terminal SER/XPAR low.

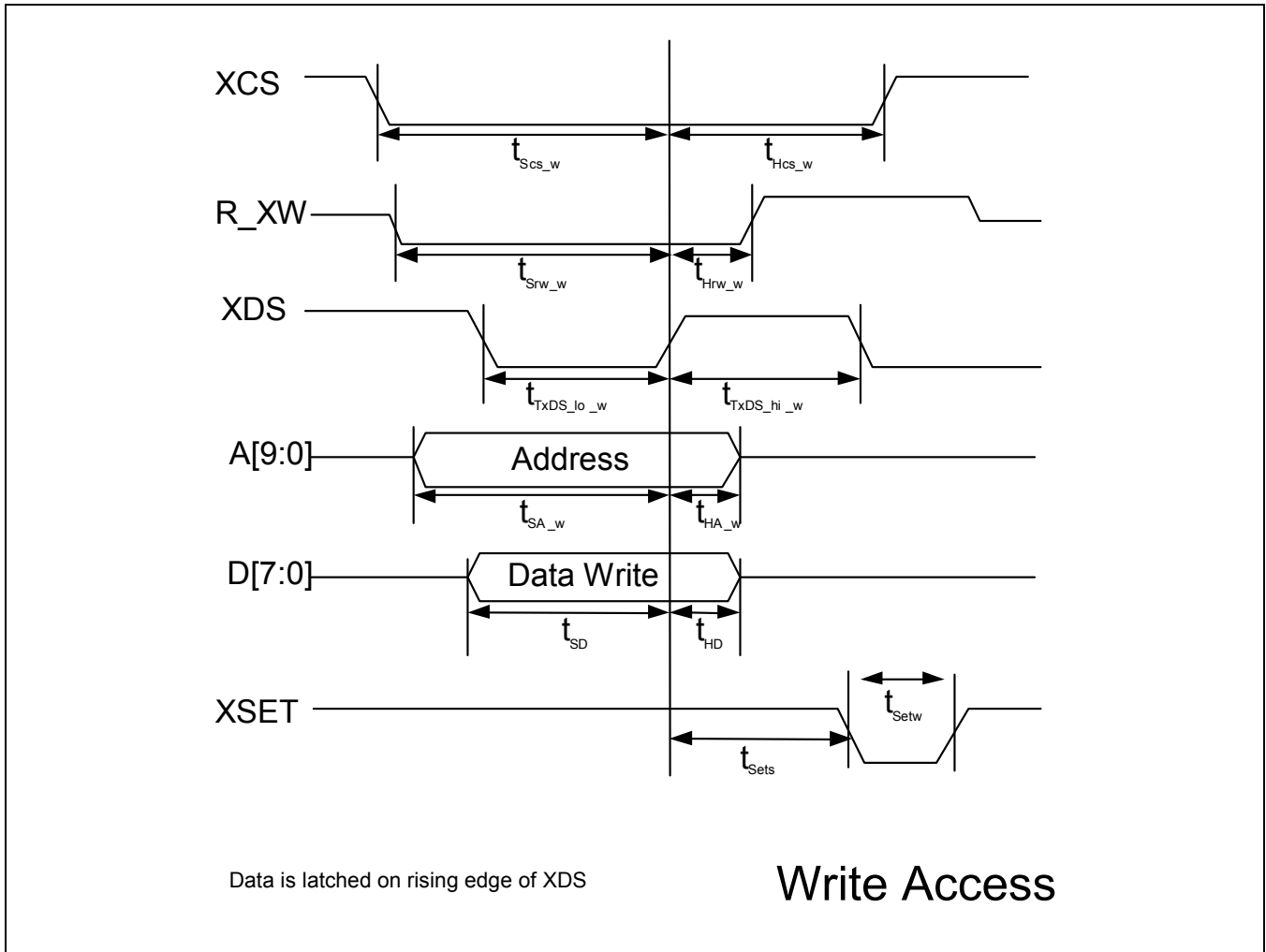
### 4.3.2 Parallel I/O Overview

A 10-bit address bus and the register contents (read or write) are transferred via a bidirectional 8-bit data bus. The active-low data strobe (XDS) latches (stores) the data into the register on the rising edge of XDS. To change the switch state, the double buffer (ICL/ACL) is transparent (mode1) when signal XDS = L in relationship to the data, consequently the switch state will change on the falling edge of signal XDS. On the rising edge of XDS, the switch state will be stored into the register.

The active low terminal XCS gates the I/O and input control signal R/XW selects either a read or write operation. [Figure 4-5](#) illustrates the timing diagram for a parallel write operation.

[Table 4-1](#) shows the parallel write timing specifications as defined in [Figure 4-5](#).

Figure 4-5. Parallel Write Timing Diagram



**Table 4-1. Parallel I/O Write Timing**

Parameter	Description	Minimum	Typical	Maximum
$t_{scs\_w}$	XCS Falling Edge before XDS Rising Edge	5 ns	—	—
$t_{hcs\_w}$	XCS Hold after Rising Edge of XDS	0 ns	—	—
$t_{hrw\_w}$	R/XW Hold after Rising Edge of XDS	0 ns	—	—
$t_{srw\_w}$	R/XW Setup before Rising Edge of XDS	9 ns	—	—
$t_{txDSL\_w}$	XDS Low Period	8 ns	—	—
$t_{txDSh\_w}$	XDS High Period	8 ns	—	—
$t_{sA\_w}$	Address Setup before Rising Edge of XDS	6 ns	—	—
$t_{hA\_w}$	Address Hold after Rising Edge of XDS	3 ns	—	—
$t_{sD\_w}$	Data Setup before Rising Edge of XDS	3 ns	—	—
$t_{hD\_w}$	Data Hold after Rising Edge of XDS	3 ns	—	—
$t_{setw}$	Hardware XSET pulse width	20 ns	—	—
$t_{sets}$	Hardware XSET setup time	3 ns	—	—



Figure 4-6 shows the timing diagram for a parallel read operation. Table 4-2 shows the parallel read timing specifications as defined in Figure 4-6.

Figure 4-6. Parallel Read Timing Diagram

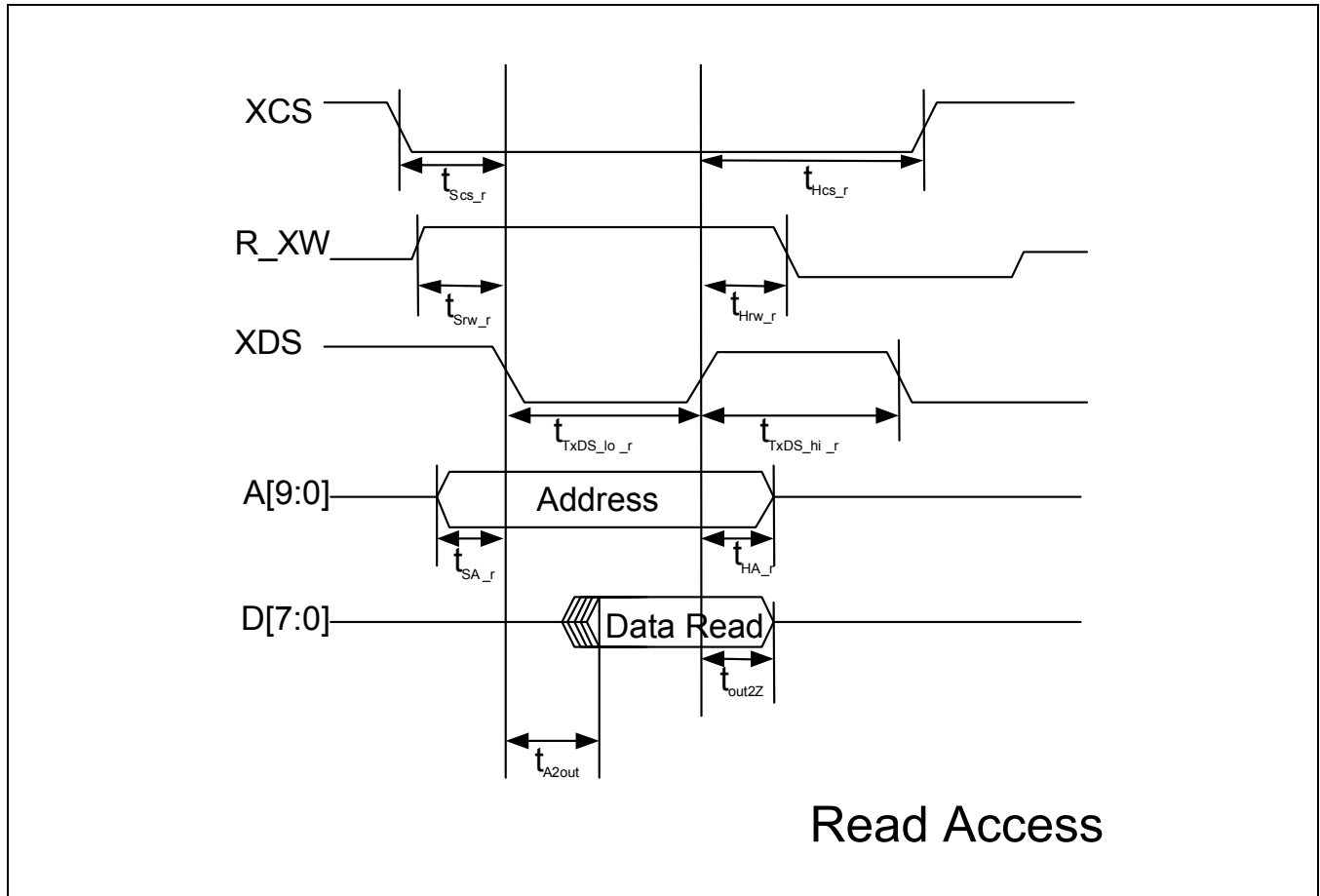


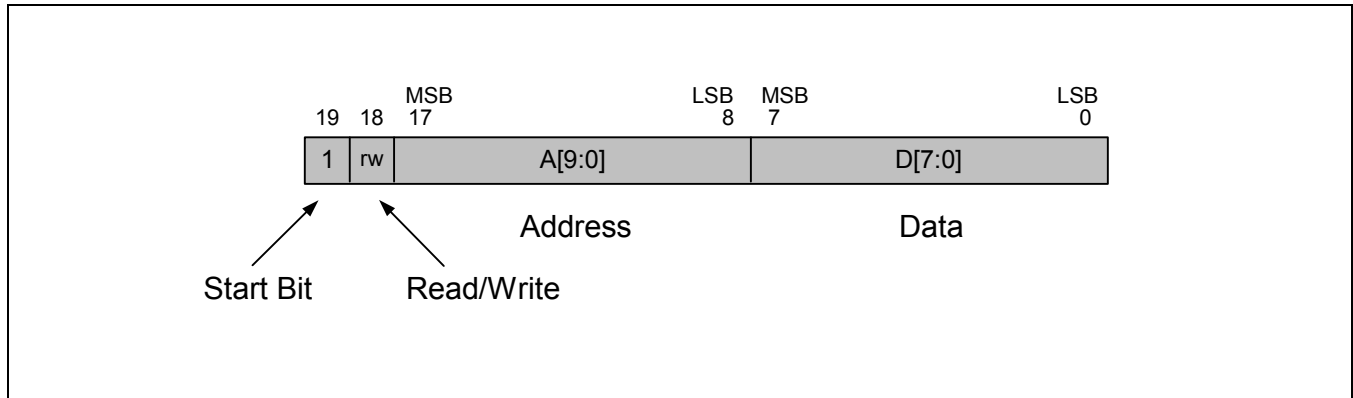
Table 4-2. Parallel I/O Read Timing

Parameter	Description	Minimum	Typical	Maximum
$t_{S_{cs\_r}}$	XCS Falling Edge before XDS Falling Edge	5 ns	—	—
$t_{H_{cs\_r}}$	XCS Hold after Rising Edge of XDS	0 ns	—	—
$t_{H_{rw\_r}}$	R/XW Hold after Rising Edge of XDS	0 ns	—	—
$t_{S_{rw\_r}}$	R/XW Setup before Falling Edge of XDS	5 ns	—	—
$t_{T_{xDSL\_r}}$	XDS Low Period	50 ns	—	—
$t_{T_{xDSH\_r}}$	XDS High Period	50 ns	—	—
$t_{S_{A\_r}}$	Address Setup before Falling Edge of XDS	9 ns	—	—
$t_{H_{A\_r}}$	Address Hold after Rising Edge of XDS	2 ns	—	—
$t_{a2out}$	Address Valid to Data Valid (on Read)	—	—	24 ns
$t_{out2Z}$	XDS Rising Edge to Data High Z	1 ns	—	8 ns

### 4.3.3 Serial I/O Overview

The serial I/O operation is gated by chip select signal XCS (on input terminal XCS). Data is shifted in on terminal SDI on the falling edge of the serial I/O clock input (terminal SCLK), and shifted out on the serial data output (terminal SDO) on the rising edge of SCLK. Addressing a register consists of the following, as shown in Figure 4-7: A 12-bit input, consisting of the first bit (start bit, SB = 1), the second bit (operation bit: OP = 1 for read, OP = 0 for write), followed by the 10-bit address (most significant bit (MSB) first).

Figure 4-7. Serial Word Format



#### 4.3.3.1 Timing Diagram Clock Set and Program Modes

To initiate a write sequence, as shown in Figure 4-8, terminal XCS goes low before the falling edge of SCLK. On each falling edge of serial I/O clock (SCLK) the 20-bit word consisting of SB = 1, OP = 0, address, and data, are latched into the input shift register. The rising edge of signal XCS must occur before the falling edge of SCLK for the last bit. Upon receipt of the last bit, one additional cycle of SCLK is necessary before the input data transfers from the input shift register to the addressed register.

If consecutive read/write cycles are being performed, it is not necessary to insert an extra clock cycle between read/write cycles, however one extra clock cycle is needed after the last data bit of the final read/write cycle to complete the operation. On a write cycle, only the first 18 bits after SB and OP are used and all bits that follow are ignored.

Figure 4-9 illustrates the serial read mode timing diagram. To initiate a read sequence, the signal on terminal XCS goes low before the falling edge of SCLK. On each falling edge of SCLK, the 12 bits consisting of SB = 1, OP = 1, and the 10-bit address are written to the serial input shift register of the M21131/M21151. On the first rising edge following the address LSB, the SB and eight bits of the data are shifted out on SDO. The first bit output on SDO for a read operation is always 0.

In a read cycle, all extra clock cycles will result in invalid data. For invalid SB/OP, the operation is undefined. The falling edge of XCS always resets the serial operation for a new read/write cycle.

Table 4-3 contains the timing specifications for the serial programming interface.

Figure 4-8. Serial Write Mode

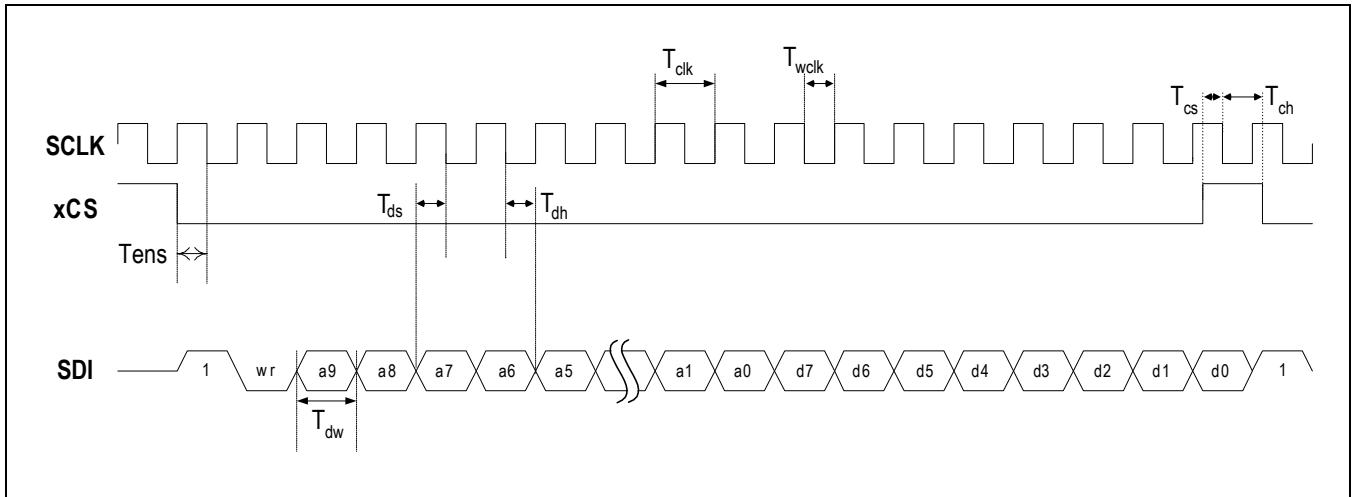
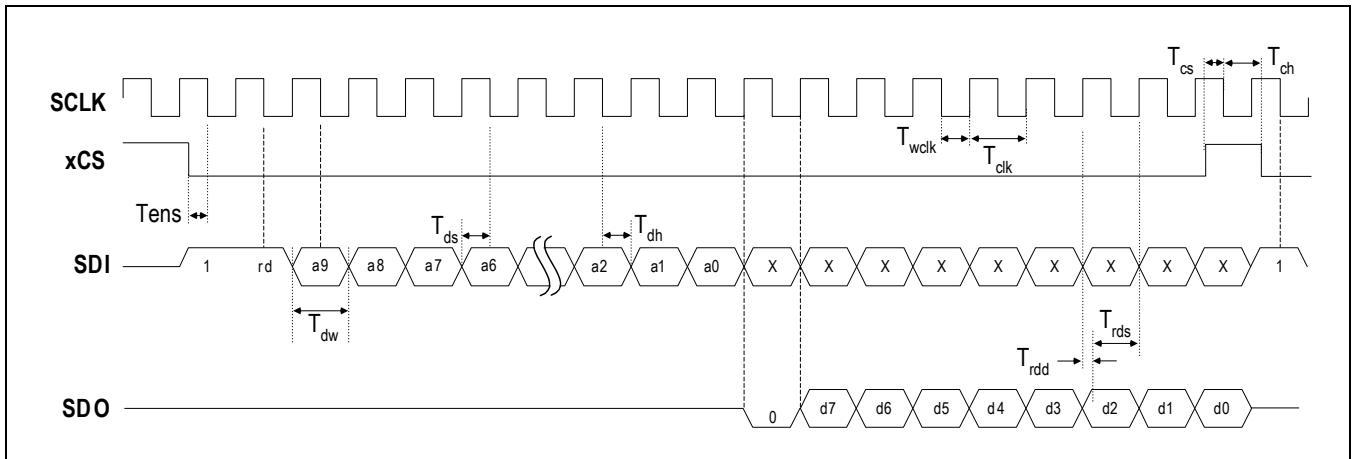


Figure 4-9. Serial Read Mode



**Table 4-3. Serial Interface Timing—Specified at Recommended Operating Conditions**

Symbol	Item	Notes	Minimum	Typical	Maximum	Units
$t_{dw}$	Data width	—	14	—	—	ns
$t_{dh}$	Data hold time	—	5	—	—	ns
$t_{ds}$	Data setup time	—	5	—	—	ns
$t_{ens}$	Enable setup time	—	5	—	—	ns
$t_{cs}$	Chip select setup time	—	2	—	$T_{clk} - 2$	ns
$t_{ch}$	Chip select hold time	—	2	—	—	ns
$t_{rDD}$	Read data output delay	—	1	—	14	ns
$t_{rds}$	Read data valid	—	9	—	—	ns
$t_{clk}$	SCLK period width	—	40	—	—	ns
$t_{wclk}$	SCLK minimum low duration	—	5	—	$T_{clk} - 5$	ns
$t_r$	Output rise time	1	1	—	4	ns
$t_f$	Output fall time	1	1	—	4	ns

**NOTES:**

- Edge rate in the high edge-rate mode.

### 4.3.4 Switch Setting

Crosspoint functions and options are accessed through hardware terminals, or software via the serial/parallel interface. In some cases, both software and hardware can access the same function. This section describes these functions in detail and [Table 3-1](#) lists register functions.

The setting parameters are summarized in [Table 3-1](#), which contains the allowable addresses for the M21131/ M21151 crosspoint switch. The INCHSEL#n register controls the crosspoint connectivity. Its register address, INCHSEL#n, is mapped to the output channel number and its associated data is the input connected to the output N. Output channels 0 through 71/0 through 143 are mapped to register addresses = 00h through 37h/00h through 8Fh with the output N = address.

For example, if register address = 05h and DATA = 02h (5h = 02h), then output #5 gets input #2. Any output can be routed to the internal PRBS receiver input and the internal PRBS transmitter output can be routed to any of the inputs. To Read the current switch state (CSS) of the ACL, the selected channel is specified by register address and the resulting data is the input channel number routed to the selected output. The Next Switch State (NSS) in the ICL, if different from the ACL, cannot be read back. The default state after power on is channel 0 broadcast to all outputs (all registers cleared).

### 4.3.5 Input/Output Enable and Output Logic Swing

The inputs and outputs have both a hardware global enable and a software global enable as well as individual I/O software controls.

Terminals XINDIS and XOUTDIS control the inputs and outputs, and are active low (disabled) with internal pull-downs (100 KΩ). When terminals XINDIS = L and/or XOUTDIS = L all inputs and/or outputs are globally disabled, respectively (default). Hardware disable has priority over all software controls. If the I/Os are not disabled via the hardware terminals, XINDIS and/or XOUTDIS = H, then the IOENABLE register selects the control status. With IOENABLE[4] = 0 (default), the software global enable/disable bits (IOENABLE[1:0] for global input) and

(IOENABLE[3:2] for global output) are selected. The individual global input and output register values default to disable.

With IOENABLE[4] = 1, the 72/144 CHANCFG#n registers control the enable/disable status of each channel input and output buffer. The CHANCFG#n address is computed with N+100h, with the variable N mapped to both the input and output channel. Consequently, CHANCFG#n[3:2] controls the enable/disable status of output N, and CHANCFG#n[1:0] controls the enable/disable status of input N. With IOENABLE[4] = 1, IOENABLE[3:2] and IOENABLE[1:0] have no meaning.

For both inputs and outputs, a disabled state implies turning off the current sources of the I/O buffer to save power. With the built-in pull-up resistors, both “p” and “n” nodes of the differential output will default to the high logic state when disabled; however, the logic levels of the “p” and “n” inputs to the switch core are undetermined.

An additional input signal inhibit function is included in the IN\_CHAN\_CTRL[3] registers (200h–237h/200h–28Fh) of the M21131/M21151. With IN\_CHAN\_CTRL[3] = 1, the “p” inputs to the switch core are clamped to a logic low and the “n” inputs are clamped to a logic high.

The output drive level is programmable on either a global or individual basis. With IOENABLE[4] = 0 (default), IOENABLE[3:2] = 00b selects a global default 500 mVp–p differential output level, and IOENABLE[3:2] = 01b selects a global default 900 mVp–p differential output level. With IOENABLE[3:2] = 10b a global 1200 mV differential output level is selected (1200 mV should not be used at AV<sub>DD\_IO</sub> = 2.5 V). With IOENABLE[3:2] = 11b (default) all outputs are disabled. A 500 mVp–p differential output implies a 250 mVp–p single-ended output. With IOENABLE[4] = 1, CHANCFG#n[3:2] selects the output level of each channel individually.

The global enable, disable, and output swing level registers minimize the software setup overhead of the crosspoint switch after resetting; however, individual control of enable/disable and output swing level is provided for maximum flexibility in some applications.

### 4.3.6 Programmable Input Equalization

In order to compensate for lossy external interconnects, the input buffers include a programmable equalization function. Register CHANCFG#n[6:5] as listed in Table 4-4, controls channel equalization for each input independently.

**Table 4-4. Equalization Control Bits**

CHANCFG#n[6:5]	Description
00	Minimum EQ (≈ 9 dB)
01	Small EQ (≈ 12 dB) (default)
10	Medium EQ (≈ 15 dB)
11	Large EQ (≈ 18 dB)

### 4.3.7 Programmable Output De-Emphasis

Similar to input equalization, each output buffer and PRBS transmitter has a programmable output de-emphasis (PE) function included. When enabled, the PE will provide a high frequency boost to the output signal, such that the data eye will be improved (more open) after a long external interconnect.

With IOENABLE[4] = 0 (address BAh), CORECTRL[2] (address BBh) globally enables/disables the PE for all outputs. CORECTRL[2] defaults to 0, PE off. The PE for PRBS transmitters are not dependant on IOENABLE[4], i.e., PRBSTXCTRL2\_N[5:3] always control PE for the PRBS transmitters. With IOENABLE[4] = 0 and CORECTRL[2] = 1, PE is globally enabled and CORECTRL[4:3] (address BBh) globally control the PE amplitude and duration for all outputs. The default PE amplitude and duration settings are CORECTRL[4] = 0 and

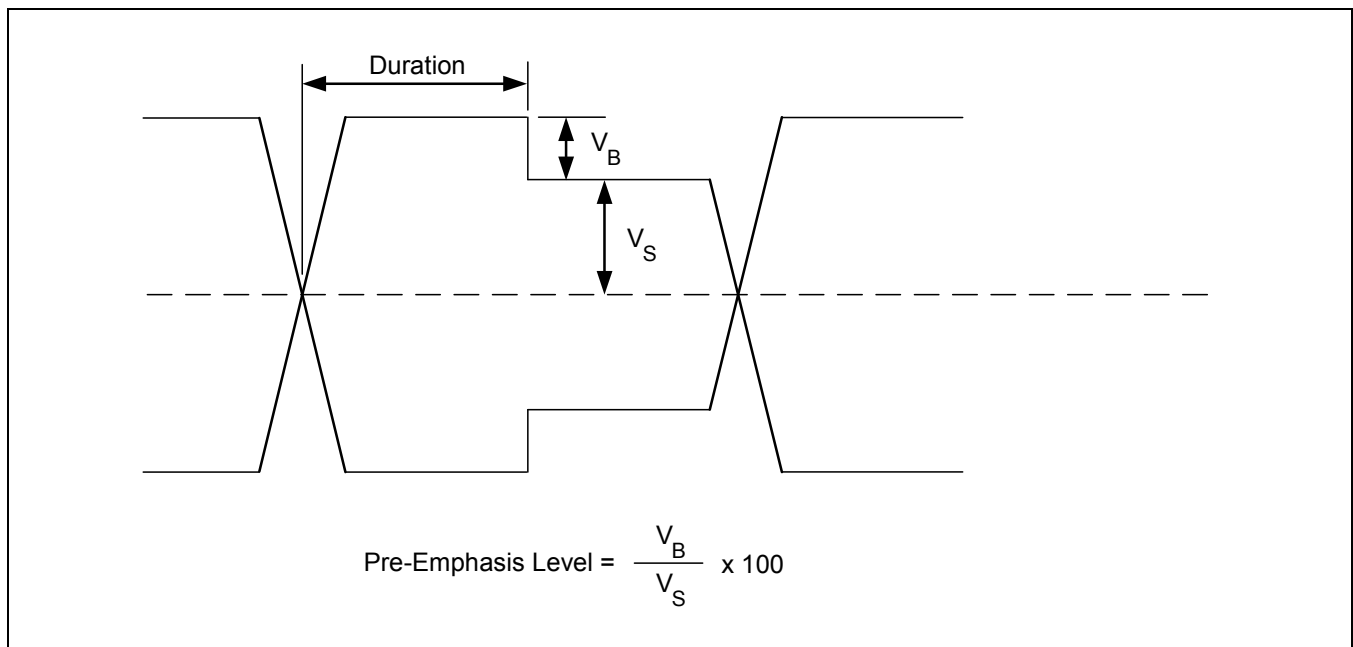
CORECTRL[3] = 1 which globally enable a PE of 50% for a duration of approximately 600 ps (see Figure 4-10). For example, if the output drive level is set for 1200 mV, when there is a data transition (1-to-0 or 0-to-1) the beginning of each pulse will start at 1200 mV and decay to 600 mV in approximately 600 ps. Setting CORECTRL[4] = 1 (PRBSTXCTRL2\_N[5] = 1) enables a higher boost of 67%. For example, if the output drive level is set for 1200 mV, the beginning of each pulse will start at 1200 mV and decay to 400 mV. CORECTRL[3] = 0 and PRBSTXCTRL2\_N[3] = 0 (default is 1) enable a longer decay time of approximately 1200 ps, corresponding to lower frequency boost. This is for interconnects which exhibit attenuation at lower frequencies.

**Table 4-5. De-Emphasis Control Bits**

Register BBh[4:3]	Description
00	50% Amplitude, 1200 ps duration.
01	50% Amplitude, 600 ps duration (default).
10	67% Amplitude, 1200 ps duration.
11	67% Amplitude, 600 ps duration.

With IOENABLE[4] = 1 (address BAh), PE on each output is individually enabled/disabled by CHANCFG#n[4]. CHANCFG#n[4] defaults to 0, PE off. The amplitude and duration of the PE on all of outputs are still controlled by CORECTRL[4:3]. The amplitude and duration of the PE on PRBS transmitters are controlled by PRBSTXCTRL2\_N[5, 3].

**Figure 4-10. Definition of De-Emphasis Levels and Duration**



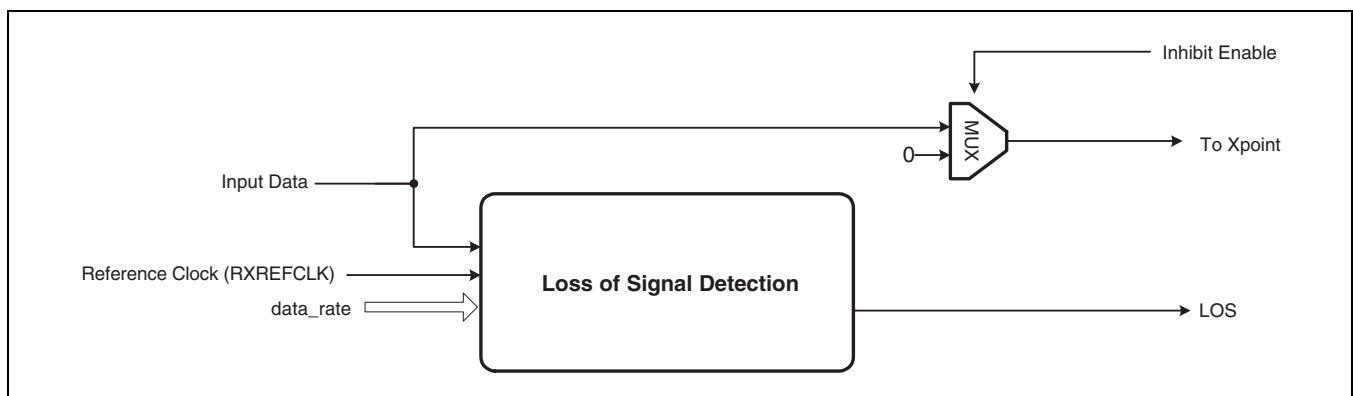
### 4.3.8 Duty Cycle Distortion (Offset) Circuit on Inputs to Switch

Each input channel has an offset circuit that can be enabled to correct for DC offset. This circuit is designed to correct duty cycle distortion (DCD) that may be present on either a single ended or differential signal at the input of the switch. It also compensates for common mode drift of the input stage over temperature and power supply variation for single ended inputs. When enabled, the offset feature removes DCD thus improving the quality of the data eye pattern. CHANCFG#n[7] at addresses 100h–137h/100h–18Fh enables the offset function.

### 4.3.9 Input Signal Activity Monitor

For operation at data rates of 1.0 Gbps to 1.6 Gbps and 2.0 Gbps to 3.2 Gbps, a loss of signal (LOS) circuit is included on each input and detects whether valid data is present. The 19.44 MHz RXREFCLK clock must be provided to the M21131/M21151 and the data rate of the signal must be programmed for the LOS feature to function properly. LOS acts as an alarm and can be used to inhibit the signal into the switch core when the data to the input terminal is lost. If the input signal is clamped high or low, or if the difference between the input data rate and the programmed data rate is greater than approximately  $\pm 100$  Mbps, the LOS alarm will be activated. Whenever valid data is present at the input, the LOS alarm is deactivated. The LOS circuit is disabled if register IN\_CHAN\_CTRL#[1] = 0 (default 1) (addresses 200h–237h/200h–28Fh). The data rate range is selected using LOS\_DR\_SEL#n[6] and the data rate is programmed using LOS\_DR\_SEL#n[5:0] (addresses 300h–337h/300h–38Fh). When register IN\_CHAN\_CTRL#[3] = 1 (default) a LOS alarm issues an inhibit signal which forces the switch input to a low state. This minimizes any noise propagating to the switch in the LOS condition.

Figure 4-11. LOS Architecture



#### 4.3.9.1 LOS Data Rate Programming

The LOS circuit for each input channel operates independently and employs an external 19.44 MHz clock reference, RXREFCLK. The LOS circuit can be programmed to any rate between 2.0 GHz and 3.2 GHz or between 1.0 GHz and 1.6 GHz using register LOS\_DR\_SEL#n[6:0] (300h–337h/300h–38Fh). To select a desired rate, it is necessary to set LOS\_DR\_SEL#n[6:0] to the value closest to the desired rate. For example if 2.64 GHz is the desired rate: LOS\_DR\_SEL#n[6] = 0 and the code to be selected (LOS\_DR\_SEL#n[5:0]) is 100010 (136d), which corresponds to 2.6438 GHz. The programmed frequency is exactly equal to the reference frequency multiplied by the decimal equivalent of the binary value programmed in register LOS\_DR\_SEL#n[5:0] + 102d. For 1.0 Gbps to 1.6 Gbps operation, the dr\_range bit, LOS\_DR\_SEL#n[6] must be set to 1. This bit causes the multiplier set by LOS\_DR\_SEL#n[5:0] to be divided by two.

**Table 4-6. Allowed Data Rates with 19.44 MHz External Reference**

RXCDR_CTRLB_N[5:0]	Notes	Bit Rate in Gbps	Multiplier
000000	1	1.983	102
000001	1	2.002	103
000010		2.022	104
...		...	...
011010		2.488	128
...		...	...
111111	1	3.208	165

**NOTE:**

- For decimal multiplier values which are not 104, 112, 120, 128, 136, 144, 152, or 160, more programming steps are required and are outlined in the “Settings for Non-Standard Rates” section and [Table 4-7](#).

### 4.3.9.2 LOS Signal Busing

Although each input channel has an individual LOS alarm, the alarms for all of the channels are wired OR on chip to create the global LOS alarm; therefore, an active LOS from one or more channels will generate a logic high on the global LOS terminal and set an alarm bit. The alarm bit can be immediately read from `los_statn[7:0]`. Toggling register `GLOBAL_CTRL[0]` from 0 to 1 then back to 0 will clear all alarm bits (unless a particular alarm persists, in which case this bit will remain high).

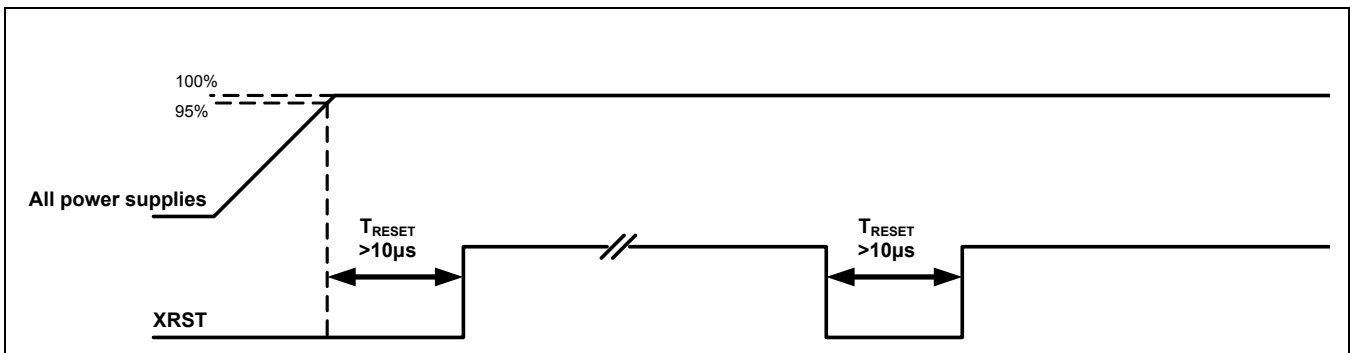
### 4.3.10 Power-Up Sequence and Device Reset

There are no power supplies sequence requirements for the M21131/M21151. Proper hardware reset assertion will ensure that the device will operate properly regardless of power supply sequence.

The XRST terminal is a hardware reset to be used after power-up or as a general reset. Before and during power-up, XRST must be set LOW.

If the device is configured to use the parallel interface for programming the registers, then upon device power-up, the XRST terminal must be held LOW for a minimum of  $T_{RESET} = 10 \mu s$  after all power supplies have reached the expected voltage level. Once XRST is set HIGH following  $T_{RESET}$ , the device reset is complete. Any hardware reset of the device after power-up can be achieved by setting terminal XRST LOW for  $T_{RESET} > 10 \mu s$  and returning it to HIGH.

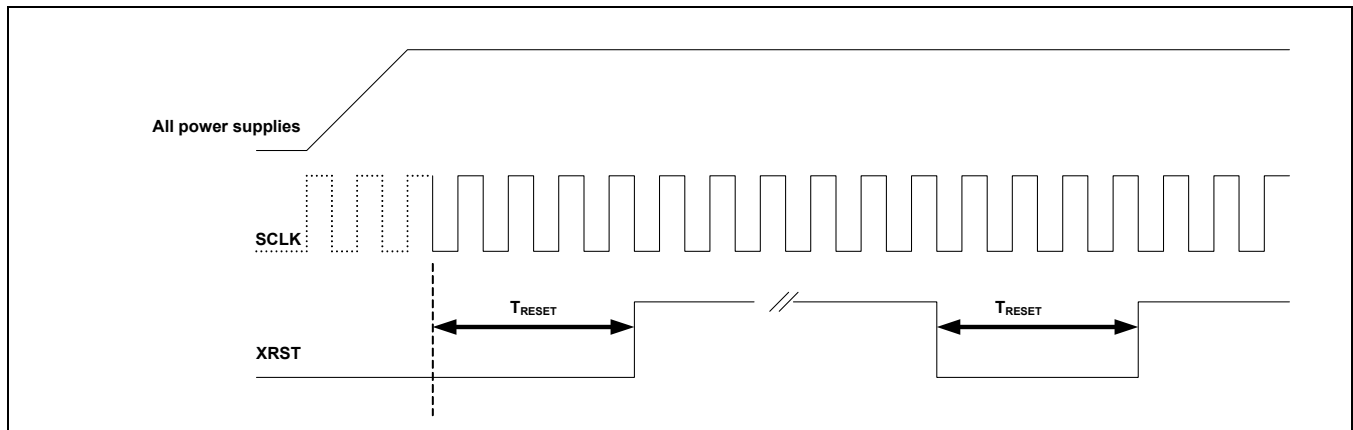
**Figure 4-12. Reset Timing in Parallel Programming Mode**





If the device is configured to use the serial interface for programming the registers (SPI), then a valid SPI clock (SCLK) must be present at the time of reset. The XRST terminal must be held LOW for a minimum of  $T_{RESET} \geq 4$  SCLK cycles, after a valid clock signal is applied. Once XRST is set HIGH following  $T_{RESET}$ , the device reset is complete. Any hardware reset of the device after power up can be achieved by setting terminal XRST LOW for at least  $T_{RESET} > 4$  SCLK cycles and returning it to HIGH.

**Figure 4-13. Reset Timing in Serial Programming Mode**



Following reset, the device will be in the following condition:

- All registers will be set to the default values.
- A software global disables of all input and output channels will be asserted (through the I/O enable register).
- Input channel 0 will be broadcast to all outputs (the ICL and ACL are cleared).
- The PRBS TX and RX will be disabled.
- All error flags will be cleared

If  $XTEST = L$  after reset, all inputs and outputs are globally enabled and the switch is set with channel 0 broadcast to all outputs. Mindspeed uses these features for internal die testing, but for normal operation, terminals  $XTEST = H$  and  $XRST = H$ . To enable a software reset, two consecutive writes to the SOFTRESET register (address, BFh) value (AAh) are required. If the second write is not to the SOFTRESET register, the register will be cleared and two additional consecutive writes of (AAh) will be needed to enable a software reset. Hardware reset has priority over software reset. A third write of any value is required to bring the switch out of reset.

### 4.3.11 Product and Revision Codes

A read to the read-only PRODCODE register causes a readback of the M21131/M21151 product code number. A read to the read-only CHIPREV register causes a readback of the version number of the chip. The contents of these registers can be used by software drivers to determine the appropriate driver routine to be used. See [Section 3.1.3](#) for details.

### 4.3.12 Core Power Saving

The CORECTRL register enables the core power-saving modes. Register  $CORECTRL[1] = 0$  powers down the switch core and the PRBS TX/RX (default power on).

Register CORECTRL[0] = 1 enables the SmartPower™ core control (default).

SmartPower automatically disables portions of the core mux circuitry that are not active for certain switch configurations. This results in a significant power savings compared to operations when the core mux is fully powered. The actual power savings will vary across configurations.

Enabling SmartPower will slightly increase the settling time of the device when a new switch core configuration is implemented, so for applications where the minimum configuration time of the switch is desired, SmartPower should be disabled. Most applications will use the M21131/M21151 with SmartPower enabled.

### 4.3.13 PRBS Transmitter and Receiver

Internally, the switch core input terminals (INP and INN) and output terminals (OUTP and OUTN) are grouped into odd and even sections, as shown in the PRBS TX and RX Functional Block Diagram, [Figure 4-14](#). Likewise, there are two PRBS transmitter (TX) and receiver (RX) sections:

An odd (1) section which operates with the odd numbered Inputs (INP1, 3, 5, etc. and INN1, 3, 5, etc.) and Outputs (OUTP1, 3, 5, etc. and OUTN1, 3, 5, etc.)

An even (0) section which operates with the even numbered Inputs (INP0, 2, 4, etc. and INN0, 2, 4, etc.) and Outputs (OUTP0, 2, 4, etc. and OUTN0, 2, 4, etc.).

As a result, there are two sets of PRBS control terminals, interface terminals and control registers. See [Table 3-1](#), Register Summary, (addresses A0 – B7) for additional information.

The references to PRBS control registers in this section apply to either the odd or even PRBS registers. As an example:

Terminal DOTXP/N[1] is the PRBS TX output of the odd (1) section and can only be routed to the odd numbered inputs. If an even numbered input is selected for PRBSTXCHSEL\_ODD[7:0], the PRBS TX output will not be connected to any odd numbered input (to connect a PRBS signal to an even numbered input, the even (0) PRBS TX section must be enabled and the PRBSTXCHSEL\_EVEN[7:0] register must be properly programmed).

Similarly, the even (0) PRBS RX section can only accept even numbered outputs (OUTP0, 2, 4, etc.). If an odd numbered output is selected for the even (0) PRBS RX, no PRBS output signal will be connected to the even (0) PRBS RX block (invalid output).

Also, note that since the RX and TX functions are completely duplicated, they can be used simultaneously in parallel. For instance, PRBS signals can be simultaneously routed into input 1 and input 71/input 1 and input 143. These two PRBS signals can then be switched to any even and any odd outputs, respectively. The respective odd and even outputs that were selected can be connected to the PRBS RX blocks. The PRBS TX and RX sections operate from 1.0 Gbps to 1.6 Gbps and 2.0 Gbps to 3.2 Gbps.

#### 4.3.13.1 PRBS TX Pattern Generation

The  $2^{23}-1$  PRBS TX (with polynomial  $D^{23}+D^{18}+1$ ) provides a NRZ PRBS pattern. The PRBS TX is enabled with register PRBSTXCTRL1[3] = 1 (default 0) or with terminal XENTX = L (CMOS level, internal pull-up). An asynchronous reset can be performed by setting PRBSTXCTRL1[4] = 1 and then bringing it low again. The data rate is determined by the external clock on terminal CLKTXP/N (PCML), by an external reference clock CLKTXREF (~19.44MHz, CMOS level) or by the recovered clock from the PRBS RX block, which is derived from its preceding CDR).

Register PRBSTXCTRL1[6:5] = 10b (default) selects the high-speed clock input, PRBSTXCTRL1[6:5] = 00b selects the low-frequency reference clock input and PRBSTXCTRL1[6:5] = 01b selects the recovered PRBS RX clock. For the case where an external low frequency clock is provided, register PRBSTXCTRL1[1] = 0 enables the TX PLL and PLL\_CTRLB[6:0] sets the actual internal clock frequency into the PRBS TX. For a 19.44 MHz

reference input, the PLL output frequency programming is described in “PRBS CDR Control Parameters” on page 59. Register PLL\_CTRLB[7] provides a PLL software reset if required.

#### 4.3.13.2 Additional Test Patterns

The PRBS TX can also output a 0101 or a 0011 pattern. By setting register PRBSTXCTRL2[1] = 1 (default 0) this mode is selected. If PRBSTXCTRL2[2] = 1 then a 0011 pattern is generated otherwise a 0101 pattern is created (default).

#### 4.3.13.3 PRBS Output Data

The output data is updated with each rising edge of CLKTXP. The output terminal Trig (CLKTXP/N divided by 16) is used as a scope trigger to observe the  $2^{23}-1$  pattern and can be disabled with Register PRBSTXCTRL2[0] = 0 (default). It is a single ended PCML output with 50Ω on chip source termination and 450 mVp-p single ended swing into an external 50Ω load.

The PRBS TX data can be observed at terminals DOTXP and DOTXN (PCML output with 50Ω on chip source termination and 900 mVp-p differential swing into an external 50Ω load) and can be routed internally to any of the inputs. When routing PRBSTX through the crosspoint core, DOTXP/N needs to be terminated with 50Ω load.

Register PRBSTXCTRL1[2] = 0 disables the PRBS TX output to be routed to any input; with PRBSTXCTRL1[2] = 1 (default).

Register PRBSTXCHSEL[7:0] selects the input to which the PRBS TX will be routed. Input channel N is selected by setting PRBSTXCHSEL[7:0] = Nh. If an invalid input is selected (N>71/143), then the PRBS TX will not be routed to any input.

Note that the PRBS TX signal will be forced into the input terminals (the on-chip PRBS buffers are operating in current mode); a portion of the PRBS signal will egress from the input terminal to which the PRBS transmitter is connected. The device normally connected to these terminals may need to be powered down (it is acceptable to have the 50Ω source termination still present) or temporarily disconnected during PRBS operation.

#### 4.3.13.4 PRBS RX Control Parameters

A  $2^{23}-1$  PRBS RX takes in a NRZ PRBS pattern (with polynomial D23+D18+1) and checks for any bit errors. The PRBS RX includes an integrated CDR which uses RXREFCLK as a low-speed reference clock.

The PRBS RX will be enabled with register PRBSRXCTRL[3] = 1 (default 0) or with terminal XENRX = L (CMOS level, internal pull-up). When enabled, the PRBS RX takes its input directly from any of the odd or even core outputs as enabled by PRBSRXCTRL[5] = 0, or from external inputs DIRXP/N enabled by PRBSRXCTRL[5] = 1 (default).

Register PRBSRXCTRL[2] = 0 prevents any of the core outputs from being connected to the PRBS RX. If register PRBSRXCTRL[2] = 1 (default), then PRBSRXCHSEL[7:0] selects which core output channel goes to the PRBS RX. In either case, the input to the PRBS RX is first routed into a dedicated CDR to resample the data and to extract a clock for the PRBS RX. Register PRBSRXCTRL[1] = 0 (default 1) enables the CDR.

#### 4.3.13.5 PRBS CDR Control Parameters

Register CDR: RXCDR\_CTRLB[6:0] controls the desired bit rate, and CDR: RXCDR\_CTRLB[7] provides a means for a software reset. The CDR must be in lock before valid data can be passed on to the actual PRBS RX circuit. Register RXCDR\_ALARMS[1:0] contain the normal CDR alarms; these bits need to be 0 for the PRBS RX to produce valid error counts. For this reason the PRBS RX needs to remain in reset while the CDR is acquiring lock. This can be done by setting register XRSTRX = L (CMOS level, internal pull-up) or with PRBSRXCTRL[4] = 1 (default 0).

The operation of the CDR for the PRBS RX section is controlled through the PRBS RX CDR Control A and Control B registers (addresses A4h, A5h, B0h, and B1h). The CDR for the PRBS RX can be reset through RXCDR\_CTRLB[7]. This bit must be set to a 1 and then set back to a 0 to issue a software reset. The LOS circuit for the PRBS RX CDR can be enabled/disabled with RXCDR\_CTRLA[1]. Bits 5, 4, 3, 2, and 0 of this register are Mindspeed reserved bits and should not be used. Bits 5, 4, and 3 should be set to 0 and bits 2 and 0 should be set to 1.

### 4.3.14 PRBS CDR Data Rate Programming

For the CDR to achieve a correct frequency acquisition, a frequency acquisition loop is present. The frequency acquisition loop employs an external clock reference, REFCLK. The external reference clock frequency should be 19.44 MHz  $\pm$ 50 ppm. The CDR is able to lock the VCO to any rate between 2.0 GHz and 3.2 GHz or from between 1.0 GHz and 1.6 GHz using register RXCDR\_CTRLB\_N[6:0] (A5h and B1h). To select a desired rate, it is necessary to set RXCDR\_CTRLB\_N[6:0] to the value closest to the desired rate. For example if 2.64 GHz is the desired rate: RXCDR\_CTRLB\_N[6] = 0 and the code to be selected (RXCDR\_CTRLB\_N[5:0]) is 100010 (136d), which corresponds to 2.6438 GHz. The programmed frequency is exactly equal to the reference frequency multiplied by the decimal equivalent of the binary value programmed in register RXCDR\_CTRLB\_N[5:0] + 102d. For 1.0–1.6 GHz operation, the half rate bit, RXCDR\_CTRLB\_N[6] must be set to 1. This bit causes the multiplier set by RXCDR\_CTRLB\_N[5:0] to be divided by two.

The Frequency Acquisition Loop is activated if the frequency difference between VCO (divided down) and the external reference clock is more than a certain value called Frequency Window. More precisely, if **LOL** = H this value is called Narrow Frequency Window (NFW) and when **LOL** = L it is called Wide Frequency Window (WFW) (WIN\_INLCK\_LOL[7:0]/WIN\_OUTLCK\_LOL[7:0]) (addresses C3h/C4h). The WFW is typically larger than NFW to provide hysteresis for the locking process. With CDRX\_CTRLA[3] = 1 (default) a LOL alarm issues the CDR inhibit which forces the CDR output to a low-logic state. When **LOL** = L the frequency acquisition loop is turned off to reduce jitter generation and to optimize phase lock. A Frequency Window Detector determines whether the VCO frequency is inside or outside the Narrow/Wide Frequency Window.

The Narrow Frequency Window and Wide Frequency Window are calculated as follows:

$$NFW = f_{refclk} \cdot \left\{ \frac{1}{(1 \pm \alpha)} - 1 \right\}, \quad \text{with} \quad \alpha = \frac{w\_inlk}{ref\_strt}$$

$$WFW = f_{refclk} \cdot \left\{ \frac{1}{(1 \pm \alpha)} - 1 \right\}, \quad \text{with} \quad \alpha = \frac{w\_inlk}{ref\_strt}$$

The default values for the narrow and wide window are 03h and 1Eh, which corresponds to 100 ppm and 1000 ppm frequency windows. The frequency acquisition time is about 1.65 ms and is limited by the 100 ppm accuracy.

#### 4.3.14.1 Settings for Non-Standard Rates

If a data rate is selected, which does not correspond to a multiplier of 104, 112, 120, 128, 136, 144, 152, or 160, then an additional write sequence is required for proper operation:

1. The VCO counter needs to have a start value different from the default value (00h). To accomplish this, the appropriate value for diff\_start from [Table 4-7](#) should be written into RXCDR\_CTRLB\_N[7:0].
2. RXCDR\_CTRLA\_N[7:6] should be changed to 11b, i.e., CFh should be written to RXCDR\_CTRLA\_N[7:0] (initial value can be 00, 01, or 10); this latches the contents of RXCDR\_CTRLB\_N into a dedicated register.

3. RXCDR\_CTRLB\_N can be used as defined in the register map in [Table 4-6](#).
4. RXCDR\_CTRLA\_N[7:6] should be reset back to 00, 01, or 10.

An individual channel soft reset will not clear the results of the diff\_start register but this write sequence must be repeated after a hardware reset or power down.

For example, for a data rate of 2.605 Gbps for the even PRBS receive CDR, the multiplier would be 134 and the following register commands would be required:

1. Write data 5Fh into register address A5h
2. Write data CFh into register address A4h
3. Write data 20h into register address A5h
4. Write data 0Fh into register address A4h

The diff\_start values as a function of the multiplier ratio are shown in [Table 4-7](#).

**Table 4-7. Diff\_start Values as a Function of the Multiplier (1 of 3)**

Multiplier	Bit Rate in Gbps	RXCDR_CTRLB[7:0] = diff_start[7:0]
102	1.983	7Fh
103	2.002	7Fh
104	2.022	00h (default)
105	2.041	13h
106	2.061	27h
107	2.080	3Bh
108	2.099	4Eh
109	2.119	62h
110	2.138	75h
111	2.158	7Fh
112	2.177	00h (default)
113	2.197	12h
114	2.216	24h
115	2.236	36h
116	2.255	49h
117	2.274	5Bh
118	2.294	6Dh
119	2.313	7Fh
120	2.333	00h (default)
121	2.352	11h
122	2.372	22h
123	2.391	33h
124	2.411	44h
125	2.430	55h

**Table 4-7. Diff\_start Values as a Function of the Multiplier (2 of 3)**

Multiplier	Bit Rate in Gbps	RXCDR_CTRLB[7:0] = diff_start[7:0]
126	2.449	66h
127	2.469	77h
128	2.488	00h (default)
129	2.508	10h
130	2.527	20h
131	2.547	30h
132	2.566	40h
133	2.586	4Fh
134	2.605	5Fh
135	2.624	6Fh
136	2.644	00h (default)
137	2.663	0Fh
138	2.683	1Eh
139	2.702	2Dh
140	2.722	3Ch
141	2.741	4Bh
142	2.760	5Ah
143	2.780	69h
144	2.799	00h (default)
145	2.819	0Eh
146	2.838	1Ch
147	2.858	2Ah
148	2.877	38h
149	2.897	47h
150	2.916	55h
151	2.935	36h
152	2.955	00h (default)
153	2.974	0Dh
154	2.994	1Bh
155	3.013	28h
156	3.033	35h
157	3.052	43h
158	3.072	50h
159	3.091	5Eh
160	3.110	00h (default)
161	3.130	0Ch

**Table 4-7. Diff\_start Values as a Function of the Multiplier (3 of 3)**

Multiplier	Bit Rate in Gbps	RXCDR_CTRLB[7:0] = diff_start[7:0]
162	3.149	19h
163	3.169	26h
164	3.188	33h
165	3.208	3Fh

Because of finite resolution in the diff\_start values, the value for WIN\_OUTLCK\_LOL[7:0] should be changed to at least 0Ah (default is 03h).

If rates are required which correspond to a non-integer multiplier (in between 2 consecutive multipliers), the CDRs can still lock to this input, as long as the closest integer multiplier is selected, and the narrow and wide frequency windows are changed to wider settings. For this purpose, each CDR has 2 individual large frequency window settings (lolwinctrl[1:0]): RXCDR\_CTRLA\_N[7:6] = 01 selects 2200/2600 ppm for the narrow and wide window of CDRx; RXCDR\_CTRLA\_N[7:6] = 10 selects 4400/5200 ppm. RXCDR\_CTRLA\_N[7:6] = 00 (default) selects the global frequency window settings of 100 ppm/1000 ppm (default).

**NOTE:**

If these wide window settings are not selected, a CDR with a data rate in between, for instance 2.488 Gbps and 2.508 Gbps, will never go out of frequency acquisition, since the frequency acquisition loop pulls the VCO to either 2.488 GHz or 2.508 GHz (depending on which multiplier was chosen) and the phase loop will pull the VCO to the exact data rate which is seen as an LOL condition (if the data rate is more than 1000 ppm away from 2.488 Gbps or 2.508 Gbps).

**4.3.14.2 PRBS Error Detection**

When the PRBS RX detects an error, terminal PERROR will go high. The first and every additional error increments an internal 8-bit counter (PRBSERROR[7:0]). If the number of errors exceeds 255 (counter overflow), the counter will remain at 255 until a hardware or software reset (powering down and then powering up) occurs. Reading the receiver error counter register requires a write of any value to copy the current contents of the error register into the PRBS error register. Subsequently, a read will yield the current error count as of the last write.

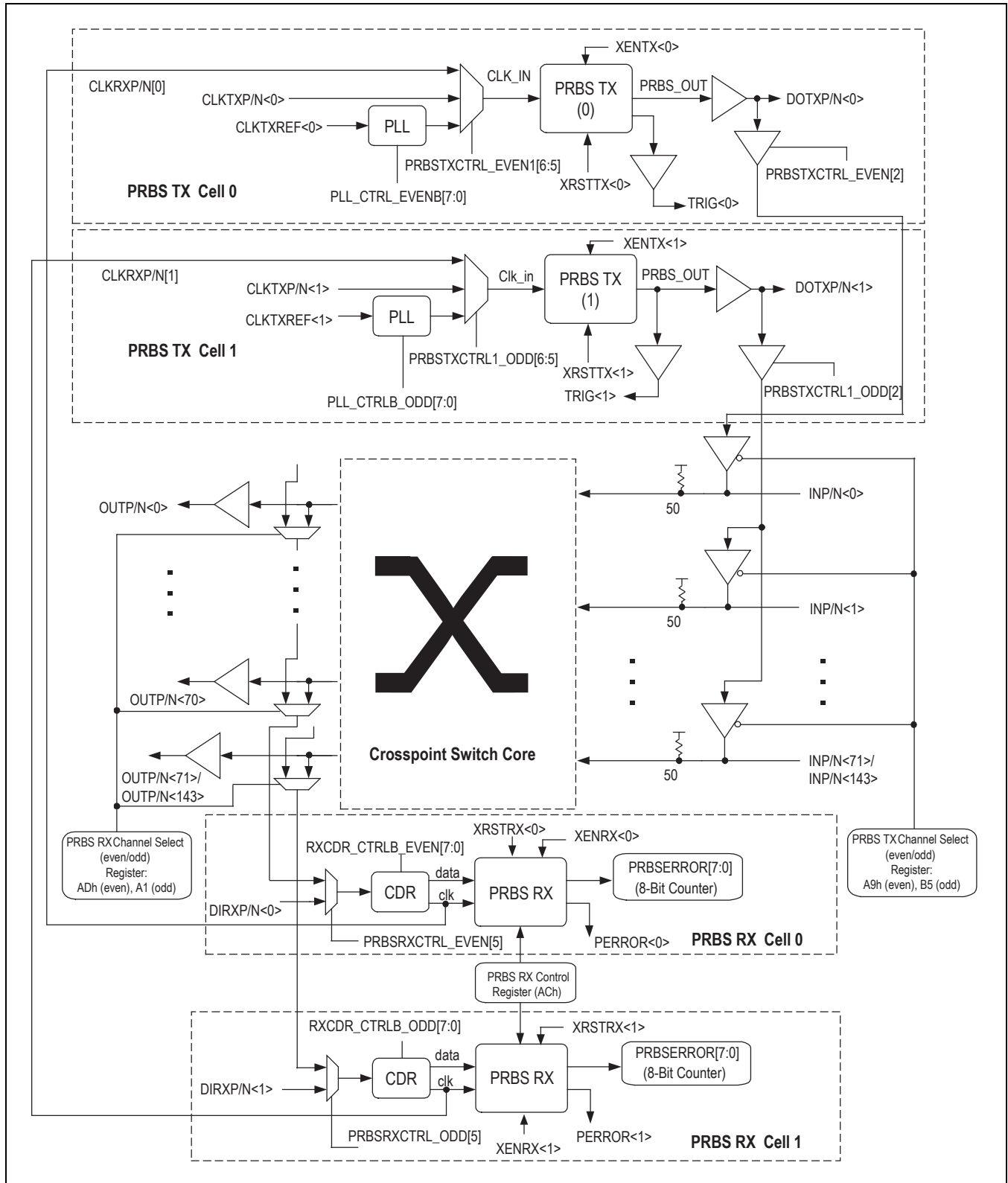
While the counter value is being read out, no additional errors will be counted. Upon PRBS reset, the PRBS receiver error counter is cleared and PERROR is reset. Register PRBSERROR[7:0] will always contain the current number of error counts. The value divided by the time of the test can be used to calculate a first order estimate of the bit error rate. If there have been more than 255 errors, the PRBSERROR register will always read FFh until cleared.

**NOTE:**

The PERROR terminal is gated with the RXCDR alarms, so that if no stable data is presented to the PRBS receiver (LOS or LOL alarm is high), this terminal will go high and will stay high until all the alarms are cleared and the PRBS receiver error counter is cleared. This enables the PRBS receiver to detect the all zeros case as an error condition.

The PRBS RX can also be configured to detect all patterns that the PRBS TX can generate. Register PRBSRXCTRL[7] = 1 (default 0) selects this mode. The input data has to be a 0101 or a 0011 repeating pattern. If it does not correspond to one of them, errors will be counted.

Figure 4-14. PRBS TX and RX Functional Block Diagram





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