Virtex-6 FPGA GTH Transceivers

User Guide

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Revision History

The following table shows the revision history for this document.

Date	Version	Revision
09/16/09	1.0	Initial Xilinx release.
02/16/10	2.0	Changed the clock domain for the RXPOWERDOWNx[1:0] ports in Table 1-2, page 15, Table 2-10, page 57, and Table 2-12, page 68. Chapter 1: Updated OTU-3 values in Table 1-1. In Table 1-2, renamed DO port to DRPDO and relocated ports I, IB, and O to new Table 1-3. Chapter 2: In the GTHRESET description in Table 2-7 and Table 2-10, indicated that GTHINIT must be pulsed only after GTHRESET is deasserted. In Table 2-10 and Table 2-12, changed RXPOWERDOWN and TXPOWERDOWN descriptions for the x4 link case. Added Reference Clock Input Structure, page 43. Removed reference to LVDS clocks as being able to drive the reference clock pins, page 44. Added sentence about MMCM and BUFR to TSTREFCLKOUT port description in Table 2-4. Added PLL, page 48. Revised Figure 2-12, Figure 2-13, and Figure 2-14. In Table 2-11, changed the meaning of bit code 110 for bits [13:11] and [10:8] of the PCS_MODE_LANE attribute to Reserved; changed the 8B/10B reset value for the PCS_RESET_LANE attribute; added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_RESET_1_LANE, bits [15:2]. In Table 2-14, added the encoding to the PMA_LPBK_CTRL_LANE attribute description; changed the Reserved bits for [13:11] and [10:8] in the PCS_MODE_LANE attribute; added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PMA_LPBK_CTRL_LANE, bits [15:2]. In Table 2-15, changed the name of port DO[15:0] to DRPDO[15:0]. Added note about DISABLEDRP to Using the DRP Interface, page 72 and Using the Management Interface, page 74. Chapter 3: Added 32 and 64 bits to 8B/10B mode in Table 3-1. Added two rows to 8B/10B Mode for 32-bit and 64-bit fabric interface data width in Table 3-2. Revised manual adjustment mode settings for the BUFFER_CONFIG_LANE attribute in Table 3-4, and changed the meaning of bit code 110 for bits [13:11] and [10:8] of the PCS_MODE_LANE attribute to Reserved in Table 3-4, Table 3-6, Table 3-8, and Table 3-10. Added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_RESET_1_LANE, bits [15:2] in Table 3-6. Changed the 8B/10B reset value for the PCS_RESET_LANE attribute in Table 3-6, Table 3-8, Table 3-10, and Table 3-12. Added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_RESET_1_LANE, bits [15:2] in Table 3-10. Changed the PCS_RESET_LANE value in step 2 of Enabling 8B/10B Mode, page 87. In Table 3-12, and added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PRBS_CFG_LANE, bits [15:4] and PCS_RESET_1_LANE, bits [15:2]; changed the Reserved bits for [13:11] and [10:8] in the PCS_MODE_LANE attribute. In Table 3-13, added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_MISC_CFG_0_LANE, bits [15:12] and [5:0]. Added TX Configurable Driver. Chapter 4: Added RX Analog Front End, RX Equalization, and RX CDR. Added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_MISC_CFG_0_LANE, bits [15:12] and [5:0] in Table 4-8, and to attributes PCS_MISC_CFG_0_LANE, bits [15:12] and [5:0], PCS_RESET_1_LANE bits [15:2], and PRBS_CFG_LANE bits [15:4] in Table 4-10. In the Functional Description section of RX Pattern Checker, added paragraph about when the checker is forced into PRBS31 mode, and added two sentences at the end of the section. Added Table 4-9. Changed the 8B/10B reset value for the PCS_RESET_LANE attribute in Table 4-10, Table 4-13, Table 4-16, and Table 4-18. Deleted PRBS checker reference in Description of RXCODEERR in Table 4-12, Table 4-15, Table 4-17, and Table 4-21. In Table 4-13, Table 4-16, Table 4-18, and Table 4-22, changed transmitter to receiver in the description of RX_FABRIC_WIDTH, and changed the meaning of bit code 110 for bits [13:11] and [10:8] of the PCS_MODE_LANE attribute to Reserved. In Table 4-13, Table 4-16, and Table 4-18, added reference to the Virtex-6 FPGA GTH Transceiver Wizard to attribute PCS_RESET_1_LANE, bits [15:2]. Changed the PCS_RESET_LANE value in step 2 of Enabling 8B/10B Mode, page 132. Added 32 and 64 bits to 8B/10B mode in Table 4-19. Added two rows to 8B/10B Mode for 32-bit and 64-bit fabric interface data width in Table 4-20. Revised manual adjustment mode settings for the BUFFER_CONFIG_LANE attribute in Table 4-22. Added Chapter 5, Board Design Guidelines.

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Date	Version	Revision
10/04/10	2.1	Chapter 1: Updated the list of supported line rates for multiple industry standards on page 11. Updated the GTHE1_QUAD columns in Figure 1-1. Removed Table 1-1: PLL Settings for Protocol Standards. Added the RXDATATAP#, RXPCSCLKSMPL#, TXDATATAP#, and TXPCSCLKSMPL# ports to Table 1-2 and changed the GTHRESET clock domain. Chapter 2: Updated the definitions for the PLL_CFG1 attribute in Table 2-3. Added lane divider settings to Table 2-6 and revised the line rate range for lane divider 4. Updated the three dividers to generate different PCS clocks on page 50. In Table 2-7, revised the GTHRESET, RXRATE#, and SAMPLERATE#, and TXRATE descriptions. In Table 2-8, revised PLL_CFG0 and PLL_CFG1 descriptions. In Table 2-9, revised the OC-48, OTU1, OTU3, and OTU4 settings and added XLAUI CAUI, and note 2. In Table 2-10, revised the GTHRESET, RXRATE#, SAMPLERATE#, and TXRATE descriptions. In Table 2-11, added LANE_PWR_CTRL_LANE#, RX_CFG1_LANE#, RX_CFG0_LANE#, MISC_CFG, and TX_CLK_SEL1_LANE#. Replaced the 1 with a 20 in the areas that require asserting the GTHRESET for 20 DCLK clock cycles (page 64 and page 65). Updated discussion under Near-end PMA Loopback section. Updated Figure 2-14. Updated descripton for PMA_LPBK_CTRL_LANE# in Table 2-14. Added a caveat on asserting GTHRESET under the Using the DRP Interface and Using the Management Interface sections. Added section on Differences Between the DRP and Management Interfaces. Chapter 3: Updated [5:0] in Table 3-13. In Table 3-15, updated descriptions for TX_PREEMPH_LANE# and TX_CFG0_LANE#. Chapter 4: Updated receiver common mode comment in Table 4-1. In Table 4-6: Updated RX_CDR_CTRL1_LANE description. In Table 4-8, updated [5:0] description. Removed RX polarity in near-end PCS loopback mode restriction from Using RX Polarity Control discussion. In Table 4-10, updated PCS_MISC_CFG_0_LANE# [5:0] description. In Table 4-11, updated register names. Chapter 5: Added sections on Board Design Guidelines – Analog Power Supply Pins, Voltage Regulators with Remote Voltage Sensing, Power Supply Distribution Network, MGTHAVCC Decoupling Capacitor Layout, Printed Circuit Board Design, and Signal BGA Breakout. Appendix A, DRP Address Map of GTH Transceivers: Added this appendix.

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About This Guide

This document describes how to use the GTH transceivers in Virtex®-6 FPGAs. In this document:

- Virtex-6 FPGA GTH transceiver is abbreviated as *GTH transceiver*.
- *GTHE1_QUAD* is the name of the instantiation primitive that instantiates one Virtex-6 FPGA GTH transceiver.
- A *Quad* is a cluster or set of four GTH transceivers that share two differential reference clock pin pairs and analog supply pins.
- *GTH lane [n]* refers to a specific lane within the GTH Quad, where n = 0, 1, 2, or 3.
- The terms *FPGA logic* and *fabric* refer to internal FPGA circuitry not including the GTH transceiver.
- The GTH transceiver's 64B/66B mode is based on the IEEE 802.3-2008 Clause 49 implementation. This mode is intended for 10 Gigabit Ethernet applications only.

Guide Contents

This manual contains the following chapters:

- Chapter 1, Transceiver and Tool Overview
- Chapter 2, Shared Transceiver Features
- Chapter 3, Transmitter
- Chapter 4, Receiver
- Chapter 5, Board Design Guidelines

Additional Documentation

The following documents are also available for download at http://www.xilinx.com/support/documentation/virtex-6.htm.

- Virtex-6 Family Overview

  The features and product selection of the Virtex-6 family are outlined in this overview.

- Virtex-6 FPGA Data Sheet: DC and Switching Characteristics

  This data sheet contains the DC and Switching Characteristic specifications for the Virtex-6 family.

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- Virtex-6 FPGA Packaging and Pinout Specifications

  This specification includes the tables for device/package combinations and maximum I/Os, pin definitions, pinout tables, pinout diagrams, mechanical drawings, and thermal specifications.

- Virtex-6 FPGA Configuration User Guide

  This all-encompassing configuration guide includes chapters on configuration interfaces (serial and SelectMAP), bitstream encryption, boundary-scan and JTAG configuration, reconfiguration techniques, and readback through the SelectMAP and JTAG interfaces.

- Virtex-6 FPGA SelectIO Resources User Guide

  This guide describes the SelectIO™ resources available in all Virtex-6 devices.

- Virtex-6 FPGA Clocking Resources User Guide

  This guide describes the clocking resources available in all Virtex-6 devices, including the MMCM and PLLs.

- Virtex-6 FPGA Memory Resources User Guide

  The functionality of the block RAM and FIFO are described in this user guide.

- Virtex-6 FPGA Configurable Logic Block User Guide

  This guide describes the capabilities of the configurable logic blocks (CLBs) available in all Virtex-6 devices.

- Virtex-6 FPGA DSP48E1 Slice User Guide

  This guide describes the architecture of the DSP48E1 slice in Virtex-6 FPGAs and provides configuration examples.

- Virtex-6 FPGA GTX Transceivers User Guide

  This guide describes the GTX transceivers available in all Virtex-6 FPGAs except the XC6VLX760.

- Virtex-6 FPGA Embedded Tri-Mode Ethernet MAC User Guide

  This guide describes the dedicated Tri-Mode Ethernet Media Access Controller available in all Virtex-6 FPGAs except the XC6VLX760.

- Virtex-6 FPGA System Monitor User Guide

  The System Monitor functionality available in all Virtex-6 devices is outlined in this guide.

- Virtex-6 FPGA PCB Designer Guide

  This guide provides information on PCB design for Virtex-6 FPGA GTX transceivers, with a focus on strategies for making design decisions at the PCB and interface level.

Additional Resources

To find additional documentation, see the Xilinx website at:

http://www.xilinx.com/support/documentation/index.htm.

To search the Answer Database of silicon, software, and IP questions and answers, or to create a technical support WebCase, see the Xilinx website at:

http://www.xilinx.com/support.

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Chapter 1

Transceiver and Tool Overview

Overview

The Virtex®-6 FPGA GTH transceiver is highly configurable and tightly integrated with the programmable logic resources of the FPGA. It provides these features to support a wide variety of applications:

- Current Mode Logic (CML) serial drivers/buffers with configurable termination and voltage swing
- Support for multiple industry standards with the following line rates:
  - 1.24 Gb/s to 1.397 Gb/s
  - 2.48 Gb/s to 2.795 Gb/s
  - 4.96 Gb/s to 5.591 Gb/s
  - 9.92 Gb/s to 11.182 Gb/s
- One PLL per GTH Quad

  GTH lanes within a Quad can be configured with different line rates that are integer multiples of each other (i.e., full line rate, line rate/2, line rate/4, and line rate/8)
- Linear equalizer with adaptive gain control and programmable boost
- Selectable DFE with three TAPs that can either be controlled manually or by an automatic adaptive engine
- Three-tap FIR filter for the TX driver

  Support for pre-cursor and post-cursor pre-emphasis
- Optional built-in PCS features
  - 8B/10B encoder/decoder with comma alignment
  - 64B/66B block based on the IEEE 802.3-2008 Clause 49 implementation
  - Raw mode (non-encoded datapath)
  - PRBS generator and checker
- Configurable fabric interface width
- DRP and management interface to access the configuration registers

The Xilinx® CORE Generator™ tool includes a Wizard to automatically configure GTH transceivers to support configurations for different protocols or perform custom configuration (see Virtex-6 FPGA GTH Transceiver Wizard, page 30).

Figure 1-1 shows the GTH transceiver placement in an example Virtex-6 FPGA device (XC6VHX255T).

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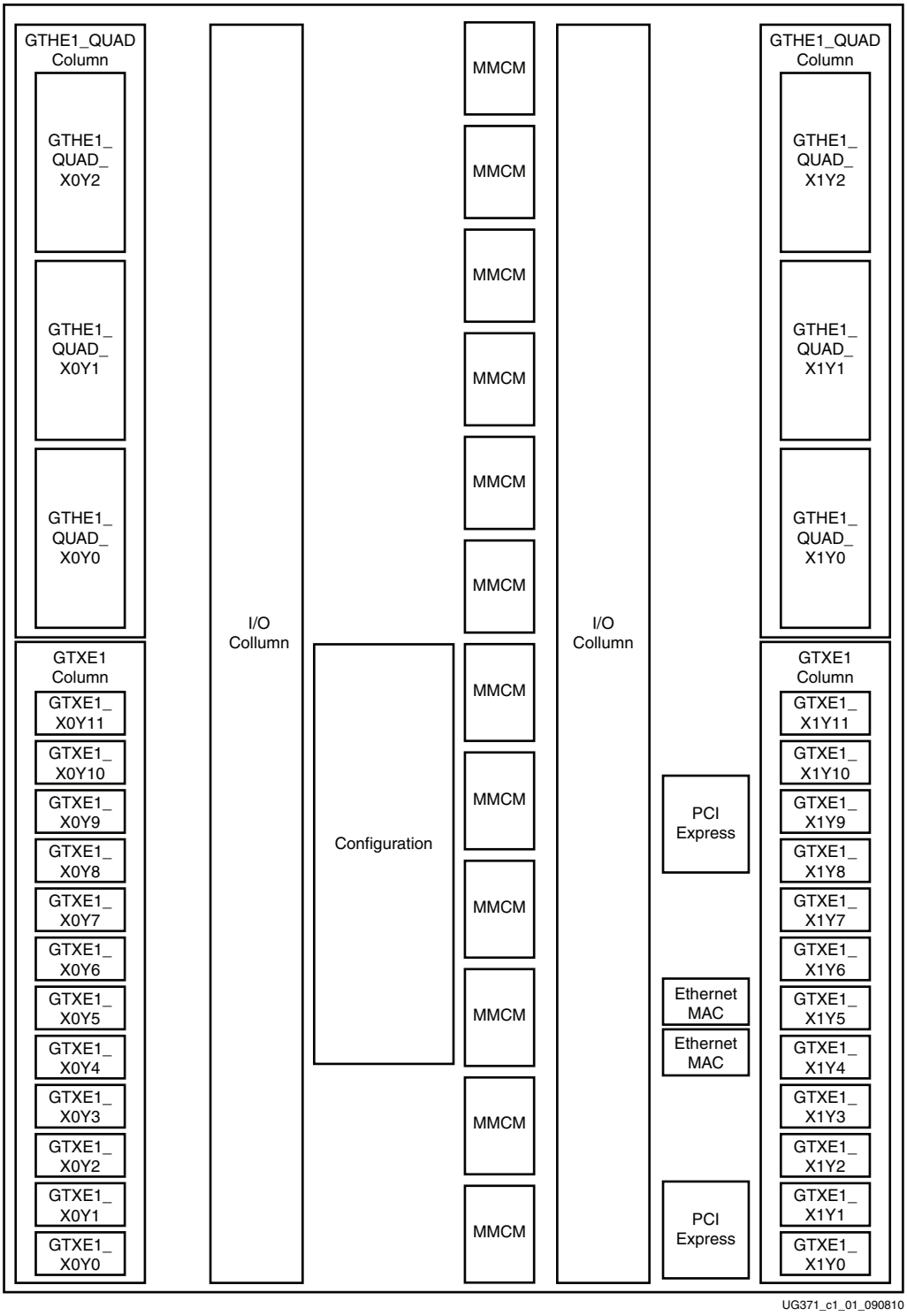

Figure 1-1: **GTH Transceiver Inside the Virtex-6 XC6VHX255T FPGA**

Notes relevant to Figure 1-1:

1. This figure does not illustrate exact size, location, or scale of the functional blocks to each other. It does show the correct number of available resources.
2. To improve clarity, this figure does not show the CLB, DSP, and block RAM columns.

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Figure 1-2 shows a diagram of the GTH Quad, containing four GTH transceivers, a PLL, and shared resources for controlling and initializing the Quad.

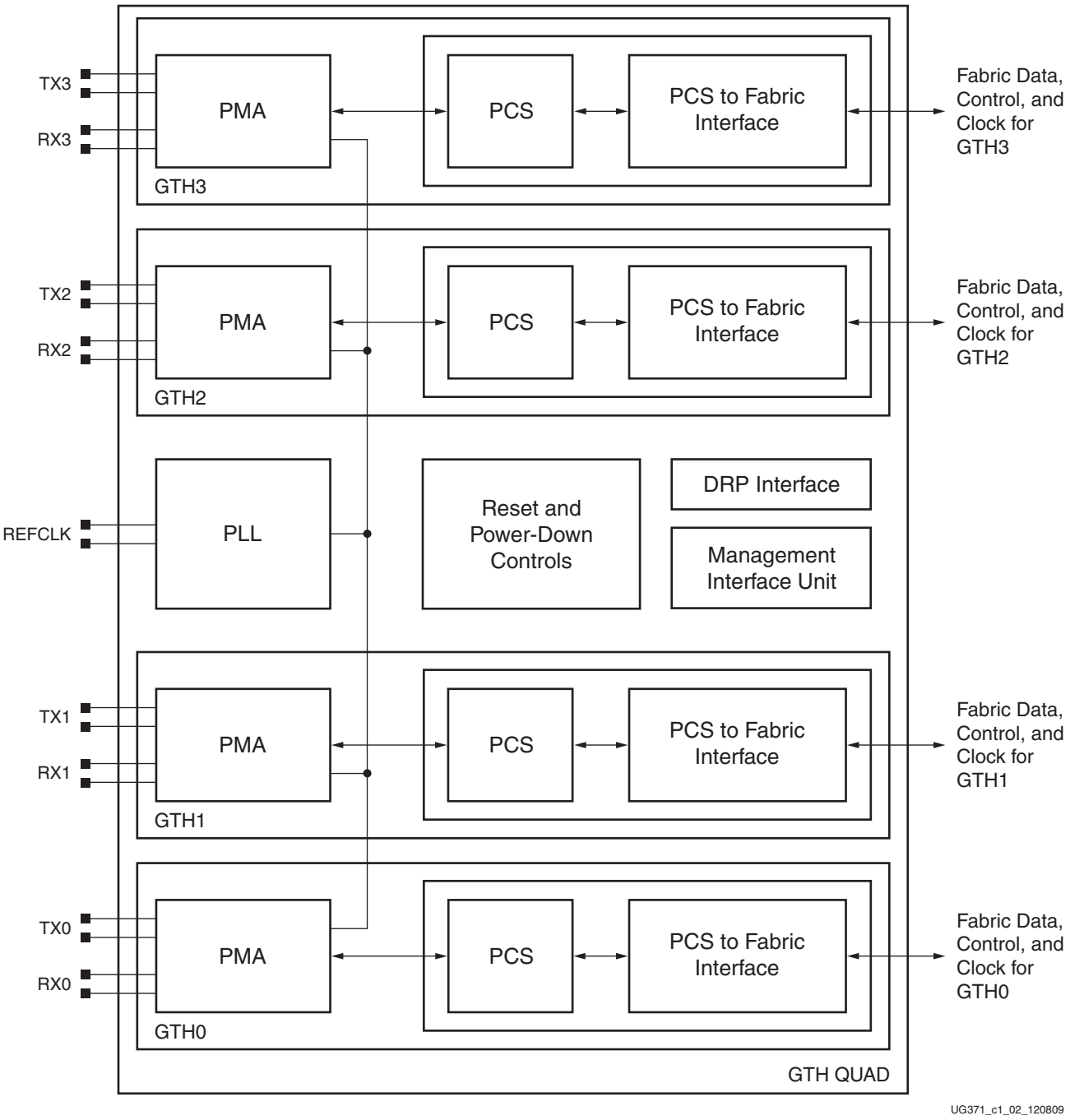

Figure 1-2: **GTH Quad Block Diagram**

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Port and Attribute Summary

This section contains alphabetical tables of power pins, ports, and attributes for the GTH transceiver.

For all ports mentioned in this guide:

- Names that end with 0 are for the GTH0 transceiver on the Quad
- Names that end with 1 are for the GTH1 transceiver on the Quad
- Names that end with 2 are for the GTH2 transceiver on the Quad
- Names that end with 3 are for the GTH3 transceiver on the Quad
- Port names that do not end with 0, 1, 2 or 3 are shared.

For all attributes mentioned in this guide:

- Names that end with LANE0 are for the GTH0 transceiver on the Quad
- Names that end with LANE1 are for the GTH1 transceiver on the Quad
- Names that end with LANE2 are for the GTH2 transceiver on the Quad
- Names that end with LANE3 are for the GTH3 transceiver on the Quad
- Attribute names that do not end with LANE0, LANE1, LANE2 or LANE3 are shared.

Table 1-1 lists alphabetically the signal names and directions of the GTH transceiver analog pins.

Table 1-1: **GTH Analog Pin Summary**

Pin	Dir
MGTHAGND_[L,R](1)	In
MGTHAVCC_[L,R](1)	In
MGTHAVCCPLL_[L,R](1)	In
MGTHAVCCRX_[L,R](1)	In
MGTHAVTT_[L,R](1)	In
MGTRBIAS	In
MGTREFCLKP/MGTREFCLKN	In
MGTTXP0/MGTTXN0	Out
MGTTXP1/MGTTXN1	
MGTTXP2/MGTTXN2	
MGTTXP3/MGTTXN3	
MGTRXP0/MGTRXN0	In
MGTRXP1/MGTRXN1	
MGTRXP2/MGTRXN2	
MGTRXP3/MGTRXN3	

Notes:

1. These are power supply pins.

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Table 1-2 lists alphabetically the signal names, directions, and clock domain of the GTH Quad ports.

Table 1-2: **GTH Quad Port Summary**

Port	Dir	Clock Domain
DADDR[15:0]	In	DCLK
DCLK	In	N/A
DEN	In	DCLK
DFETRAINCTRL0	In	DCLK
DFETRAINCTRL1		
DFETRAINCTRL2		
DFETRAINCTRL3		
DI[15:0]	In	DCLK
DISABLEDRP	In	DCLK
DRPDO[15:0]	Out	DCLK
DRDY	Out	DCLK
DWE	In	DCLK
GTHINIT	In	DCLK
GTHINITDONE	Out	DCLK
GTHRESET	In	DCLK
GTHX2LANE01	In	Async
GTHX2LANE23	In	Async
GTHX4LANE	In	Async
MGMTPCSLANESEL[3:0]	In	DCLK
MGMTPCSMMDADDR[4:0]	In	DCLK
MGMTPCSRDACK	Out	DCLK
MGMTPCSRDDATA[15:0]	Out	DCLK
MGMTPCSREGADDR[15:0]	In	DCLK
MGMTPCSREGRD	In	DCLK
MGMTPCSREGWR	In	DCLK
MGMTPCSWRDATA[15:0]	In	DCLK
PLLPCSCLKDIV[5:0]	In	DCLK
PLLREFCLKSEL[2:0]	In	DCLK

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Table 1-2: **GTH Quad Port Summary *(Cont'd)***

Port	Dir	Clock Domain
POWERDOWN0	In	TXUSERCLKIN0
POWERDOWN1		TXUSERCLKIN1
POWERDOWN2		TXUSERCLKIN2
POWERDOWN3		TXUSERCLKIN3
REFCLK	In	N/A
RXBUFRESET0	In	RXUSERCLKIN0
RXBUFRESET1		RXUSERCLKIN1
RXBUFRESET2		RXUSERCLKIN2
RXBUFRESET3		RXUSERCLKIN3
RXCODEERR0[7:0]	Out	RXUSERCLKIN0
RXCODEERR1[7:0]		RXUSERCLKIN1
RXCODEERR2[7:0]		RXUSERCLKIN2
RXCODEERR3[7:0]		RXUSERCLKIN3
RXCTRL0[7:0]	Out	RXUSERCLKIN0
RXCTRL1[7:0]		RXUSERCLKIN1
RXCTRL2[7:0]		RXUSERCLKIN2
RXCTRL3[7:0]		RXUSERCLKIN3
RXCTRLACK0	Out	TXUSERCLKIN0
RXCTRLACK1		TXUSERCLKIN1
RXCTRLACK2		TXUSERCLKIN2
RXCTRLACK3		TXUSERCLKIN3
RXDATA0[63:0]	Out	RXUSERCLKIN0
RXDATA1[63:0]		RXUSERCLKIN1
RXDATA2[63:0]		RXUSERCLKIN2
RXDATA3[63:0]		RXUSERCLKIN3
RXDATATAP0	Out	Async
RXDATATAP1		Async
RXDATATAP2		Async
RXDATATAP3		Async
RXDISPERR0[7:0]	Out	RXUSERCLKIN0
RXDISPERR1[7:0]		RXUSERCLKIN1
RXDISPERR2[7:0]		RXUSERCLKIN2
RXDISPERR3[7:0]		RXUSERCLKIN3

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Table 1-2: **GTH Quad Port Summary *(Cont'd)***

Port	Dir	Clock Domain
RXENCOMMADET0	In	RXUSERCLKIN0
RXENCOMMADET1		RXUSERCLKIN1
RXENCOMMADET2		RXUSERCLKIN2
RXENCOMMADET3		RXUSERCLKIN3
RXN0	In (Pad)	RX Serial Clock
RXN1		
RXN2		
RXN3		
RXP0		
RXP1		
RXP2		
RXP3		
RXPCSCLKSMPL0	Out	Async
RXPCSCLKSMPL1		Async
RXPCSCLKSMPL2		Async
RXPCSCLKSMPL3		Async
RXPOLARITY0	In	RXUSERCLKIN0
RXPOLARITY1		RXUSERCLKIN1
RXPOLARITY2		RXUSERCLKIN2
RXPOLARITY3		RXUSERCLKIN3
RXPOWERDOWN0[1:0]	In	TXUSERCLKIN0
RXPOWERDOWN1[1:0]		TXUSERCLKIN1
RXPOWERDOWN2[1:0]		TXUSERCLKIN2
RXPOWERDOWN3[1:0]		TXUSERCLKIN3
RXRATE0[1:0]	In	TXUSERCLKIN0
RXRATE1[1:0]		TXUSERCLKIN1
RXRATE2[1:0]		TXUSERCLKIN2
RXRATE3[1:0]		TXUSERCLKIN3
RXSLIP0	In	RXUSERCLKIN0
RXSLIP1		RXUSERCLKIN1
RXSLIP2		RXUSERCLKIN2
RXSLIP3		RXUSERCLKIN3

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Table 1-2: **GTH Quad Port Summary *(Cont'd)***

Port	Dir	Clock Domain
RXUSERCLKIN0	In	N/A
RXUSERCLKIN1		
RXUSERCLKIN2		
RXUSERCLKIN3		
RXUSERCLKOUT0	Out	N/A
RXUSERCLKOUT1		
RXUSERCLKOUT2		
RXUSERCLKOUT3		
RXVALID0[7:0]	Out	RXUSERCLKIN0
RXVALID1[7:0]		RXUSERCLKIN1
RXVALID2[7:0]		RXUSERCLKIN2
RXVALID3[7:0]		RXUSERCLKIN3
SAMPLERATE0[2:0]	In	TXUSERCLKIN0
SAMPLERATE1[2:0]		TXUSERCLKIN1
SAMPLERATE2[2:0]		TXUSERCLKIN2
SAMPLERATE3[2:0]		TXUSERCLKIN3
TSTPATH	Out	Async
TSTREFCLKFAB	Out	N/A
TSTREFCLKOUT	Out	N/A
TXBUFRESET0	In	TXUSERCLKIN0
TXBUFRESET1		TXUSERCLKIN1
TXBUFRESET2		TXUSERCLKIN2
TXBUFRESET3		TXUSERCLKIN3
TXCTRL0[7:0]	In	TXUSERCLKIN0
TXCTRL1[7:0]		TXUSERCLKIN1
TXCTRL2[7:0]		TXUSERCLKIN2
TXCTRL3[7:0]		TXUSERCLKIN3
TXCTRLACK0	Out	TXUSERCLKIN0
TXCTRLACK1		TXUSERCLKIN1
TXCTRLACK2		TXUSERCLKIN2
TXCTRLACK3		TXUSERCLKIN3

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Table 1-2: **GTH Quad Port Summary *(Cont'd)***

Port	Dir	Clock Domain
TXDATA0[63:0]	In	TXUSERCLKIN0
TXDATA1[63:0]		TXUSERCLKIN1
TXDATA2[63:0]		TXUSERCLKIN2
TXDATA3[63:0]		TXUSERCLKIN3
TXDATAMSB0[7:0]	In	TXUSERCLKIN0
TXDATAMSB1[7:0]		TXUSERCLKIN1
TXDATAMSB2[7:0]		TXUSERCLKIN2
TXDATAMSB3[7:0]		TXUSERCLKIN3
TXDATATAP10	Out	Async
TXDATATAP11		Async
TXDATATAP12		Async
TXDATATAP13		Async
TXDATATAP20	Out	Async
TXDATATAP21		Async
TXDATATAP22		Async
TXDATATAP23		Async
TXDEEMPH0	In	TXUSERCLKIN0
TXDEEMPH1		TXUSERCLKIN1
TXDEEMPH2		TXUSERCLKIN2
TXDEEMPH3		TXUSERCLKIN3
TXMARGIN0[2:0]	In	TXUSERCLKIN0
TXMARGIN1[2:0]		TXUSERCLKIN1
TXMARGIN2[2:0]		TXUSERCLKIN2
TXMARGIN3[2:0]		TXUSERCLKIN3
TXN0	Out (Pad)	TX Serial Clock
TXN1		
TXN2		
TXN3		
TXP0		
TXP1		
TXP2		
TXP3		

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Table 1-2: **GTH Quad Port Summary *(Cont'd)***

Port	Dir	Clock Domain
TXPCSCLKSMPL0	Out	Async
TXPCSCLKSMPL1		Async
TXPCSCLKSMPL2		Async
TXPCSCLKSMPL3		Async
TXPOWERDOWN0[1:0]	In	TXUSERCLKIN0
TXPOWERDOWN1[1:0]		TXUSERCLKIN1
TXPOWERDOWN2[1:0]		TXUSERCLKIN2
TXPOWERDOWN3[1:0]		TXUSERCLKIN3
TXRATE0[1:0]	In	TXUSERCLKIN0
TXRATE1[1:0]		TXUSERCLKIN1
TXRATE2[1:0]		TXUSERCLKIN2
TXRATE3[1:0]		TXUSERCLKIN3
TXUSERCLKIN0	In	N/A
TXUSERCLKIN1		
TXUSERCLKIN2		
TXUSERCLKIN3		
TXUSERCLKOUT0	Out	N/A
TXUSERCLKOUT1		
TXUSERCLKOUT2		
TXUSERCLKOUT3		

The ports in Table 1-3 are part of the GTH IBUFDS primitive.

Table 1-3: **GTH Reference Clock (IBUFDS_GTHE1) Port Summary**

Port	Dir	Clock Domain
I	In	Async
IB	In	Async
O	Out	Async

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Table 1-4 lists alphabetically the attribute names and type of the GTH Quad attributes.

Table 1-4: **GTH Quad Attribute Summary**

Attribute	Type
BER_CONST_PTRN0	16-bit Hex
BER_CONST_PTRN1	16-bit Hex
BUFFER_CONFIG_LANE0	16-bit Hex
BUFFER_CONFIG_LANE1	
BUFFER_CONFIG_LANE2	
BUFFER_CONFIG_LANE3	
DFE_TRAIN_CTRL_LANE0	16-bit Hex
DFE_TRAIN_CTRL_LANE1	
DFE_TRAIN_CTRL_LANE2	
DFE_TRAIN_CTRL_LANE3	
DLL_CFG0	16-bit Hex
DLL_CFG1	16-bit Hex
E10GBASEKR_LD_COEFF_UPD_LANE0	16-bit Hex
E10GBASEKR_LD_COEFF_UPD_LANE1	
E10GBASEKR_LD_COEFF_UPD_LANE2	
E10GBASEKR_LD_COEFF_UPD_LANE3	
E10GBASEKR_LP_COEFF_UPD_LANE0	16-bit Hex
E10GBASEKR_LP_COEFF_UPD_LANE1	
E10GBASEKR_LP_COEFF_UPD_LANE2	
E10GBASEKR_LP_COEFF_UPD_LANE3	
E10GBASEKR_PMA_CTRL_LANE0	16-bit Hex
E10GBASEKR_PMA_CTRL_LANE1	
E10GBASEKR_PMA_CTRL_LANE2	
E10GBASEKR_PMA_CTRL_LANE3	
E10GBASEKX_CTRL_LANE0	16-bit Hex
E10GBASEKX_CTRL_LANE1	
E10GBASEKX_CTRL_LANE2	
E10GBASEKX_CTRL_LANE3	
E10GBASER_PCS_CFG_LANE0	16-bit Hex
E10GBASER_PCS_CFG_LANE1	
E10GBASER_PCS_CFG_LANE2	
E10GBASER_PCS_CFG_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
E10GBASER_PCS_SEEDA0_LANE0	16-bit Hex
E10GBASER_PCS_SEEDA0_LANE1	
E10GBASER_PCS_SEEDA0_LANE2	
E10GBASER_PCS_SEEDA0_LANE3	
E10GBASER_PCS_SEEDA1_LANE0	16-bit Hex
E10GBASER_PCS_SEEDA1_LANE1	
E10GBASER_PCS_SEEDA1_LANE2	
E10GBASER_PCS_SEEDA1_LANE3	
E10GBASER_PCS_SEEDA2_LANE0	16-bit Hex
E10GBASER_PCS_SEEDA2_LANE1	
E10GBASER_PCS_SEEDA2_LANE2	
E10GBASER_PCS_SEEDA2_LANE3	
E10GBASER_PCS_SEEDA3_LANE0	16-bit Hex
E10GBASER_PCS_SEEDA3_LANE1	
E10GBASER_PCS_SEEDA3_LANE2	
E10GBASER_PCS_SEEDA3_LANE3	
E10GBASER_PCS_SEEDB0_LANE0	16-bit Hex
E10GBASER_PCS_SEEDB0_LANE1	
E10GBASER_PCS_SEEDB0_LANE2	
E10GBASER_PCS_SEEDB0_LANE3	
E10GBASER_PCS_SEEDB1_LANE0	16-bit Hex
E10GBASER_PCS_SEEDB1_LANE1	
E10GBASER_PCS_SEEDB1_LANE2	
E10GBASER_PCS_SEEDB1_LANE3	
E10GBASER_PCS_SEEDB2_LANE0	16-bit Hex
E10GBASER_PCS_SEEDB2_LANE1	
E10GBASER_PCS_SEEDB2_LANE2	
E10GBASER_PCS_SEEDB2_LANE3	
E10GBASER_PCS_SEEDB3_LANE0	16-bit Hex
E10GBASER_PCS_SEEDB3_LANE1	
E10GBASER_PCS_SEEDB3_LANE2	
E10GBASER_PCS_SEEDB3_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
E10GBASER_PCS_TEST_CTRL_LANE0	16-bit Hex
E10GBASER_PCS_TEST_CTRL_LANE1	
E10GBASER_PCS_TEST_CTRL_LANE2	
E10GBASER_PCS_TEST_CTRL_LANE3	
E10GBASEX_PCS_TSTCTRL_LANE0	16-bit Hex
E10GBASEX_PCS_TSTCTRL_LANE1	
E10GBASEX_PCS_TSTCTRL_LANE2	
E10GBASEX_PCS_TSTCTRL_LANE3	
GLBL0_NOISE_CTRL	16-bit Hex
GLBL_AMON_SEL	16-bit Hex
GLBL_DMON_SEL	16-bit Hex
GLBL_PWR_CTRL	16-bit Hex
GTH_CFG_PWRUP_LANE0	1-bit Binary
GTH_CFG_PWRUP_LANE1	
GTH_CFG_PWRUP_LANE2	
GTH_CFG_PWRUP_LANE3	
LANE_AMON_SEL	16-bit Hex
LANE_DMON_SEL	16-bit Hex
LANE_LNK_CFGOVRD	16-bit Hex
LANE_PWR_CTRL_LANE0	16-bit Hex
LANE_PWR_CTRL_LANE1	
LANE_PWR_CTRL_LANE2	
LANE_PWR_CTRL_LANE3	
LNK_TRN_CFG_LANE0	16-bit Hex
LNK_TRN_CFG_LANE1	
LNK_TRN_CFG_LANE2	
LNK_TRN_CFG_LANE3	
LNK_TRN_COEFF_REQ_LANE0	16-bit Hex
LNK_TRN_COEFF_REQ_LANE1	
LNK_TRN_COEFF_REQ_LANE2	
LNK_TRN_COEFF_REQ_LANE3	
MISC_CFG	16-bit Hex
MODE_CFG1	16-bit Hex
MODE_CFG2	16-bit Hex
MODE_CFG3	16-bit Hex

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
MODE_CFG4	16-bit Hex
MODE_CFG5	16-bit Hex
MODE_CFG6	16-bit Hex
MODE_CFG7	16-bit Hex
PCS_ABILITY_LANE0	16-bit Hex
PCS_ABILITY_LANE1	
PCS_ABILITY_LANE2	
PCS_ABILITY_LANE3	
PCS_CTRL1_LANE0	16-bit Hex
PCS_CTRL1_LANE1	
PCS_CTRL1_LANE2	
PCS_CTRL1_LANE3	
PCS_CTRL2_LANE0	16-bit Hex
PCS_CTRL2_LANE1	
PCS_CTRL2_LANE2	
PCS_CTRL2_LANE3	
PCS_MISC_CFG_0_LANE0	16-bit Hex
PCS_MISC_CFG_0_LANE1	
PCS_MISC_CFG_0_LANE2	
PCS_MISC_CFG_0_LANE3	
PCS_MISC_CFG_1_LANE0	16-bit Hex
PCS_MISC_CFG_1_LANE1	
PCS_MISC_CFG_1_LANE2	
PCS_MISC_CFG_1_LANE3	
PCS_MODE_LANE0	16-bit Hex
PCS_MODE_LANE1	
PCS_MODE_LANE2	
PCS_MODE_LANE3	
PCS_RESET_LANE0	16-bit Hex
PCS_RESET_LANE1	
PCS_RESET_LANE2	
PCS_RESET_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
PCS_RESET_1_LANE0	16-bit Hex
PCS_RESET_1_LANE1	
PCS_RESET_1_LANE2	
PCS_RESET_1_LANE3	
PCS_TYPE_LANE0	16-bit Hex
PCS_TYPE_LANE1	
PCS_TYPE_LANE2	
PCS_TYPE_LANE3	
PLL_CFG0	16-bit Hex
PLL_CFG1	16-bit Hex
PLL_CFG2	16-bit Hex
PMA_CTRL1_LANE0	16-bit Hex
PMA_CTRL1_LANE1	
PMA_CTRL1_LANE2	
PMA_CTRL1_LANE3	
PMA_CTRL2_LANE0	16-bit Hex
PMA_CTRL2_LANE1	
PMA_CTRL2_LANE2	
PMA_CTRL2_LANE3	
PMA_LPBK_CTRL_LANE0	16-bit Hex
PMA_LPBK_CTRL_LANE1	
PMA_LPBK_CTRL_LANE2	
PMA_LPBK_CTRL_LANE3	
PRBS_BER_CFG0_LANE0	16-bit Hex
PRBS_BER_CFG0_LANE1	
PRBS_BER_CFG0_LANE2	
PRBS_BER_CFG0_LANE3	
PRBS_BER_CFG1_LANE0	16-bit Hex
PRBS_BER_CFG1_LANE1	
PRBS_BER_CFG1_LANE2	
PRBS_BER_CFG1_LANE3	
PRBS_CFG_LANE0	16-bit Hex
PRBS_CFG_LANE1	
PRBS_CFG_LANE2	
PRBS_CFG_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
PTRN_CFG0_LSB	16-bit Hex
PTRN_CFG0_MSB	16-bit Hex
PTRN_LEN_CFG	16-bit Hex
PWRUP_DLY	16-bit Hex
RX_AEQ_VAL0_LANE0	16-bit Hex
RX_AEQ_VAL0_LANE1	
RX_AEQ_VAL0_LANE2	
RX_AEQ_VAL0_LANE3	
RX_AEQ_VAL1_LANE0	16-bit Hex
RX_AEQ_VAL1_LANE1	
RX_AEQ_VAL1_LANE2	
RX_AEQ_VAL1_LANE3	
RX_AGC_CTRL_LANE0	16-bit Hex
RX_AGC_CTRL_LANE1	
RX_AGC_CTRL_LANE2	
RX_AGC_CTRL_LANE3	
RX_CDR_CTRL0_LANE0	16-bit Hex
RX_CDR_CTRL0_LANE1	
RX_CDR_CTRL0_LANE2	
RX_CDR_CTRL0_LANE3	
RX_CDR_CTRL1_LANE0	16-bit Hex
RX_CDR_CTRL1_LANE1	
RX_CDR_CTRL1_LANE2	
RX_CDR_CTRL1_LANE3	
RX_CDR_CTRL2_LANE0	16-bit Hex
RX_CDR_CTRL2_LANE1	
RX_CDR_CTRL2_LANE2	
RX_CDR_CTRL2_LANE3	
RX_CFG0_LANE0	16-bit Hex
RX_CFG0_LANE1	
RX_CFG0_LANE2	
RX_CFG0_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
RX_CFG1_LANE0	16-bit Hex
RX_CFG1_LANE1	
RX_CFG1_LANE2	
RX_CFG1_LANE3	
RX_CFG2_LANE0	16-bit Hex
RX_CFG2_LANE1	
RX_CFG2_LANE2	
RX_CFG2_LANE3	
RX_CTLE_CTRL_LANE0	16-bit Hex
RX_CTLE_CTRL_LANE1	
RX_CTLE_CTRL_LANE2	
RX_CTLE_CTRL_LANE3	
RX_CTRL_OVRD_LANE0	16-bit Hex
RX_CTRL_OVRD_LANE1	
RX_CTRL_OVRD_LANE2	
RX_CTRL_OVRD_LANE3	
RX_FABRIC_WIDTH0	Integer
RX_FABRIC_WIDTH1	
RX_FABRIC_WIDTH2	
RX_FABRIC_WIDTH3	
RX_LOOP_CTRL_LANE0	16-bit Hex
RX_LOOP_CTRL_LANE1	
RX_LOOP_CTRL_LANE2	
RX_LOOP_CTRL_LANE3	
RX_MVAL0_LANE0	16-bit Hex
RX_MVAL0_LANE1	
RX_MVAL0_LANE2	
RX_MVAL0_LANE3	
RX_MVAL1_LANE0	16-bit Hex
RX_MVAL1_LANE1	
RX_MVAL1_LANE2	
RX_MVAL1_LANE3	
RX_P0_CTRL	16-bit Hex
RX_P0S_CTRL	16-bit Hex
RX_P1_CTRL	16-bit Hex

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
RX_P2_CTRL	16-bit Hex
RX_PI_CTRL0	16-bit Hex
RX_PI_CTRL1	16-bit Hex
SIM_GTHRESET_SPEEDUP	Integer
SIM_VERSION	String
SLICE_CFG	16-bit Hex
SLICE_NOISE_CTRL_0_LANE01	16-bit Hex
SLICE_NOISE_CTRL_0_LANE23	
SLICE_NOISE_CTRL_1_LANE01	16-bit Hex
SLICE_NOISE_CTRL_1_LANE23	
SLICE_NOISE_CTRL_2_LANE01	16-bit Hex
SLICE_NOISE_CTRL_2_LANE23	
SLICE_TX_RESET_LANE01	16-bit Hex
SLICE_TX_RESET_LANE23	
TERM_CTRL_LANE0	16-bit Hex
TERM_CTRL_LANE1	
TERM_CTRL_LANE2	
TERM_CTRL_LANE3	
TX_CFG0_LANE0	16-bit Hex
TX_CFG0_LANE1	
TX_CFG0_LANE2	
TX_CFG0_LANE3	
TX_CFG1_LANE0	16-bit Hex
TX_CFG1_LANE1	
TX_CFG1_LANE2	
TX_CFG1_LANE3	
TX_CFG2_LANE0	16-bit Hex
TX_CFG2_LANE1	
TX_CFG2_LANE2	
TX_CFG2_LANE3	
TX_CLK_SEL0_LANE0	16-bit Hex
TX_CLK_SEL0_LANE1	
TX_CLK_SEL0_LANE2	
TX_CLK_SEL0_LANE3	

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Table 1-4: **GTH Quad Attribute Summary *(Cont'd)***

Attribute	Type
TX_CLK_SEL1_LANE0	16-bit Hex
TX_CLK_SEL1_LANE1	
TX_CLK_SEL1_LANE2	
TX_CLK_SEL1_LANE3	
TX_DISABLE_LANE0	16-bit Hex
TX_DISABLE_LANE1	
TX_DISABLE_LANE2	
TX_DISABLE_LANE3	
TX_FABRIC_WIDTH0	Integer
TX_FABRIC_WIDTH1	
TX_FABRIC_WIDTH2	
TX_FABRIC_WIDTH3	
TX_P0P0S_CTRL	16-bit Hex
TX_P1P2_CTRL	16-bit Hex
TX_PREEMPH_LANE0	16-bit Hex
TX_PREEMPH_LANE1	
TX_PREEMPH_LANE2	
TX_PREEMPH_LANE3	
TX_PWR_RATE_OVRD_LANE0	16-bit Hex
TX_PWR_RATE_OVRD_LANE1	
TX_PWR_RATE_OVRD_LANE2	
TX_PWR_RATE_OVRD_LANE3	

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Virtex-6 FPGA GTH Transceiver Wizard

The Virtex-6 FPGA GTH Transceiver Wizard is the preferred tool to generate a wrapper to instantiate a GTH transceiver primitive called `GTHE1_QUAD`. The Wizard can be found in the CORE Generator tool. The user is recommended to download the most up-to-date IP update before using the Wizard. Details on how to use this Wizard can be found in UG691, *Virtex-6 FPGA GTH Transceiver Wizard Getting Started Guide*.

1. Start the CORE Generator tool.
2. Locate the Virtex-6 FPGA GTH Transceiver Wizard in the taxonomy tree under:
   `/FPGA Features & Design/IO Interfaces` (see Figure 1-1, page 12).

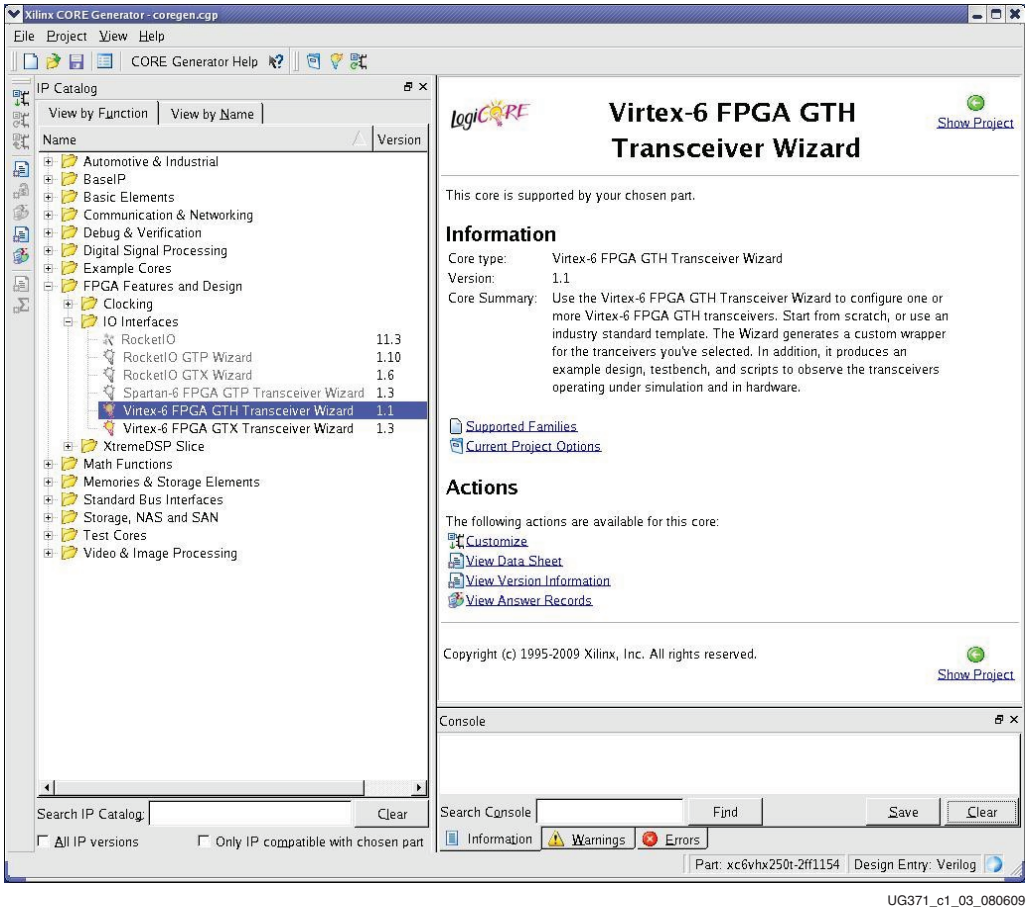

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Figure 1-3: **Virtex-6 FPGA GTH Transceiver Wizard**

3. Double-click **Virtex-6 FPGA GTH Transceiver Wizard** to launch the Wizard.

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Simulation

Functional Description

For simulating a design with GTH transceivers, SecureIP libraries must be compiled using the COMPXLIB tool. For more details on SecureIP, COMPXLIB, and setting up the simulation environment, refer to UG626, *Synthesis and Simulation Design Guide*.

Ports and Attributes

There are no simulation-only ports.

The `GTHE1_QUAD` primitive has attributes intended only for simulation. Table 1-5 lists the simulation-only attributes of the `GTHE1_QUAD` primitive. The names of these attributes start with *SIM_*.

Table 1-5: **Simulation Attributes**

Attribute	Type	Description
SIM_GTHRESET_SPEEDUP	Integer	This attribute shortens the number of DCLK cycles required to finish the GTHRESET sequence during simulation (deassertion of GTHRESET to the assertion of GTHINITDONE). `0`: The GTHRESET sequence is simulated with its original duration (standard initialization is approximately 360 µs for a 50 MHz DCLK). `1`: The GTHRESET cycle time is shortened (fast initialization is approximately 50 µs for a 50 MHz DCLK).
SIM_VERSION	Real	This attribute selects the simulation version to match different steppings of silicon. The default for this attribute is 1.0.

Implementation

Functional Description

This section provides the information needed to map Virtex-6 FPGA GTH transceivers instantiated in a design to device resources, including:

- The location of the GTH transceiver on the available device and package combinations.
- The pad numbers of external signals associated with each GTH transceiver.
- How the GTH Quad and clocking resources instantiated in a design are mapped to available locations with a user constraints file (UCF).

It is a common practice to define the location of the GTH Quad early in the design process to ensure correct usage of clock resources and to facilitate signal integrity analysis during board design. The implementation flow facilitates this practice through the use of location constraints in the UCF.

While this section describes how to instantiate GTH clocking components, the details of the different GTH transceiver clocking options are discussed in Reference Clock Distribution and Selection, page 45.

The position of the GTH Quad is specified by an XY coordinate system that describes the column number and its relative position within that column. In the Virtex-6 HXT device,

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there are packages with all the GTH Quads located in a single column along one side of the die, and other packages with all GTH Quads located on both the left column (X0) and right column (X1) of the die.

There are two ways to create a UCF for designs that use the GTH transceiver. The preferred method is to use the Virtex-6 FPGA GTH Transceiver Wizard (see Virtex-6 FPGA GTH Transceiver Wizard, page 30). The Wizard automatically generates a UCF file from the example design. The UCF file generated by the Wizard can then be edited to customize operating parameters and placement information for the application.

The second approach is to create the UCF by hand. When using this approach, the designer must enter the location constraint for the GTH transceiver used in the application.

Figure 1-4 through Figure 1-12, page 41 provide the GTH Quad position information for all available device and package combinations along with the pad numbers for the external signals associated with each GTH lane of the Quad. The list of device and package include:

- XC6VHX255T-FF1155
- XC6VHX255T-FF1923
- XC6VHX380T-FF1155
- XC6VHX380T-FF1923
- XC6VHX380T-FF1924
- XC6VHX565T-FF1923
- XC6VHX565T-FF1924

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FF1155 Package Diagrams

Figure 1-4 through Figure 1-6, page 35 show the placement diagrams for the FF1155 package.

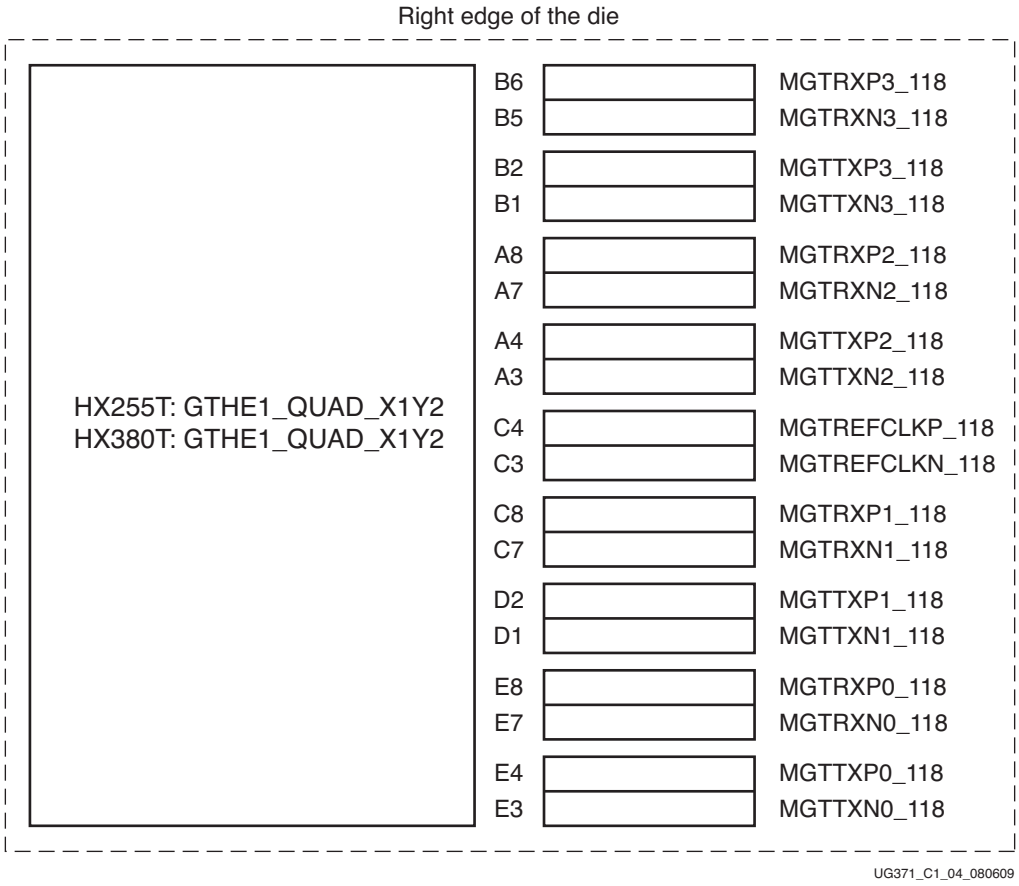

Figure 1-4: **Placement Diagram for the FF1155 Package (1 of 3)**

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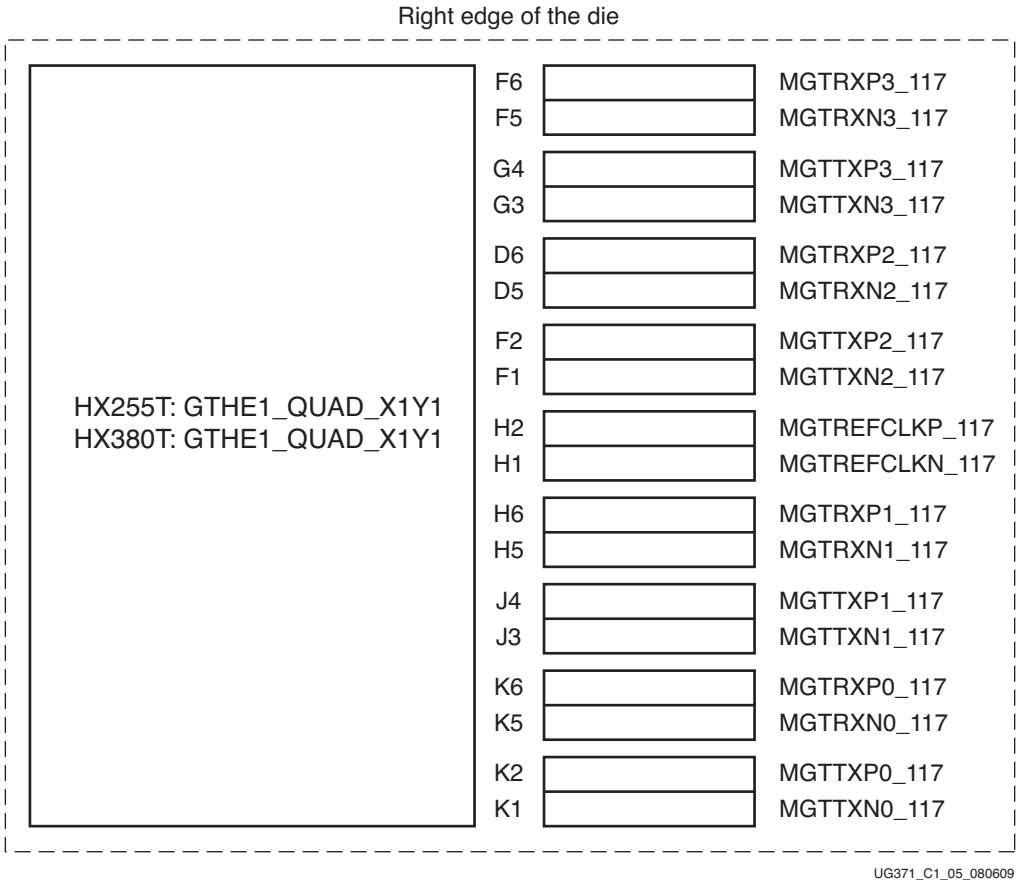

Figure 1-5: **Placement Diagram for the FF1155 Package (2 of 3)**

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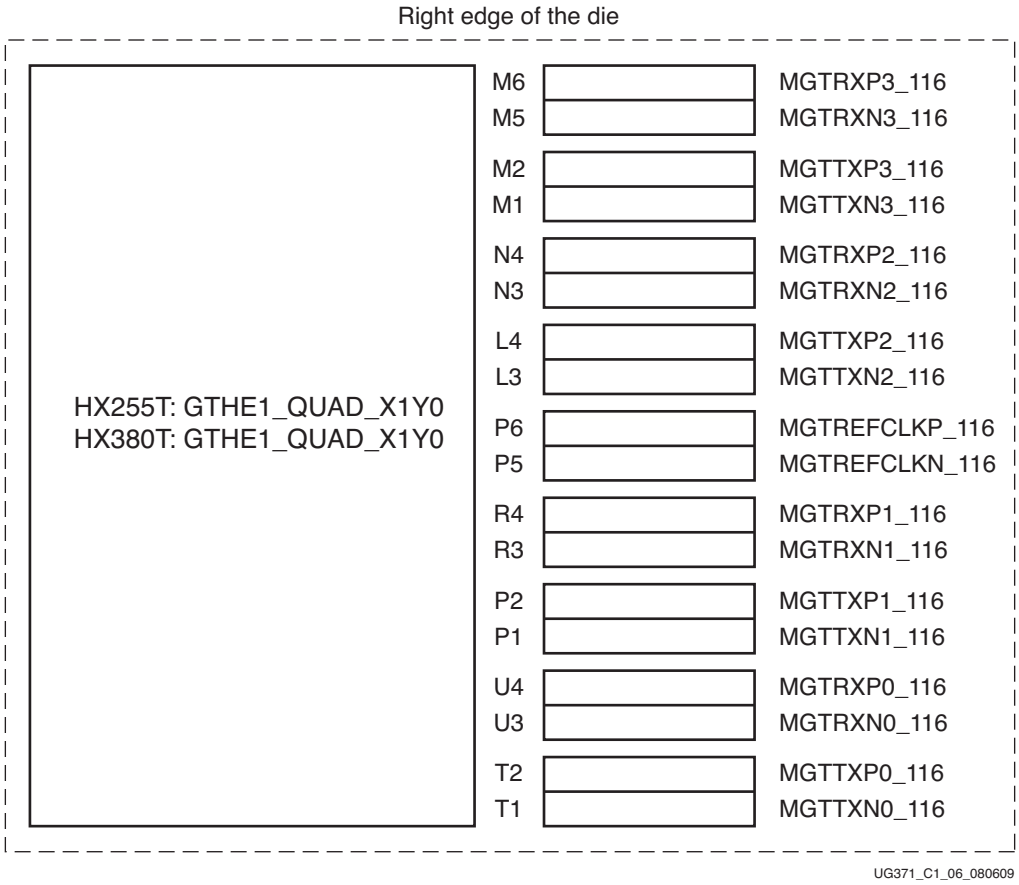

Figure 1-6: **Placement Diagram for the FF1155 Package (3 of 3)**

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FF1923 and FF1924 Package Diagrams

Figure 1-7 through Figure 1-12, page 41 show the placement diagrams for the FF1923 and FF1924 packages. The XC6VHX255T device is available only in the FF1923 package.

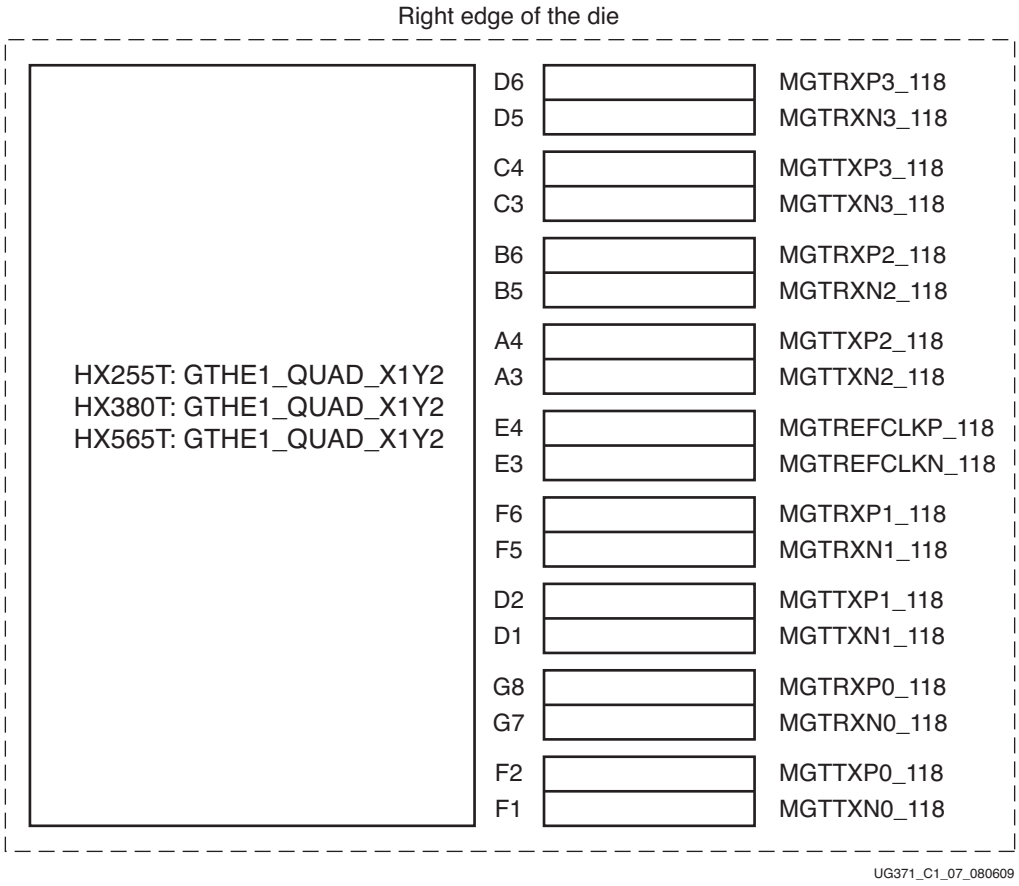

Figure 1-7: **Placement Diagram for the FF1923 and FF1924 Packages (1 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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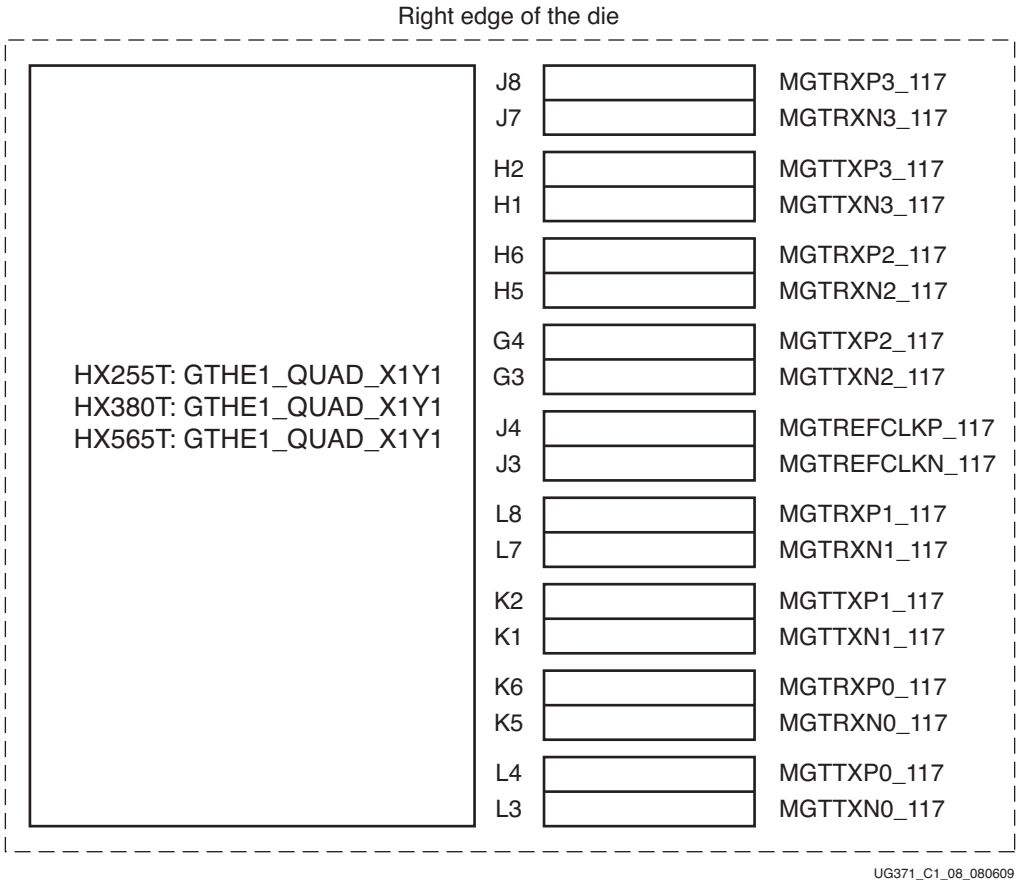

Figure 1-8: **Placement Diagram for the FF1923 and FF1924 Packages (2 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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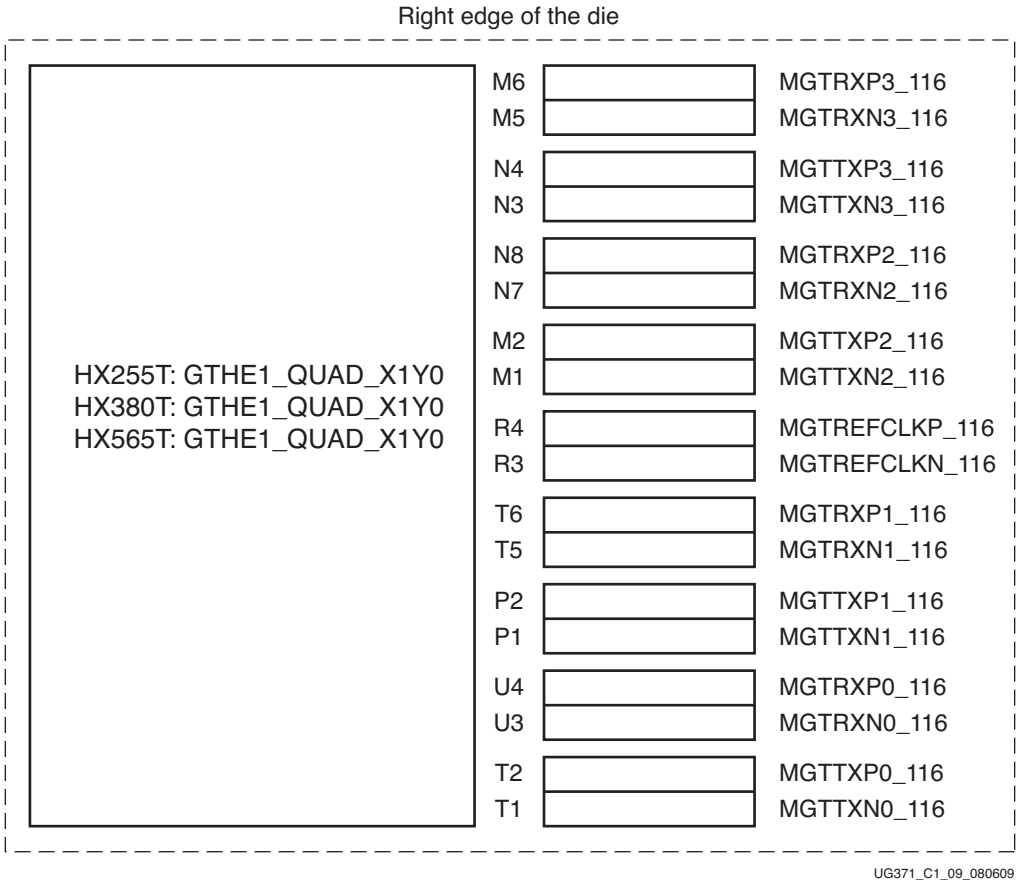

Figure 1-9: **Placement Diagram for the FF1923 and FF1924 Packages (3 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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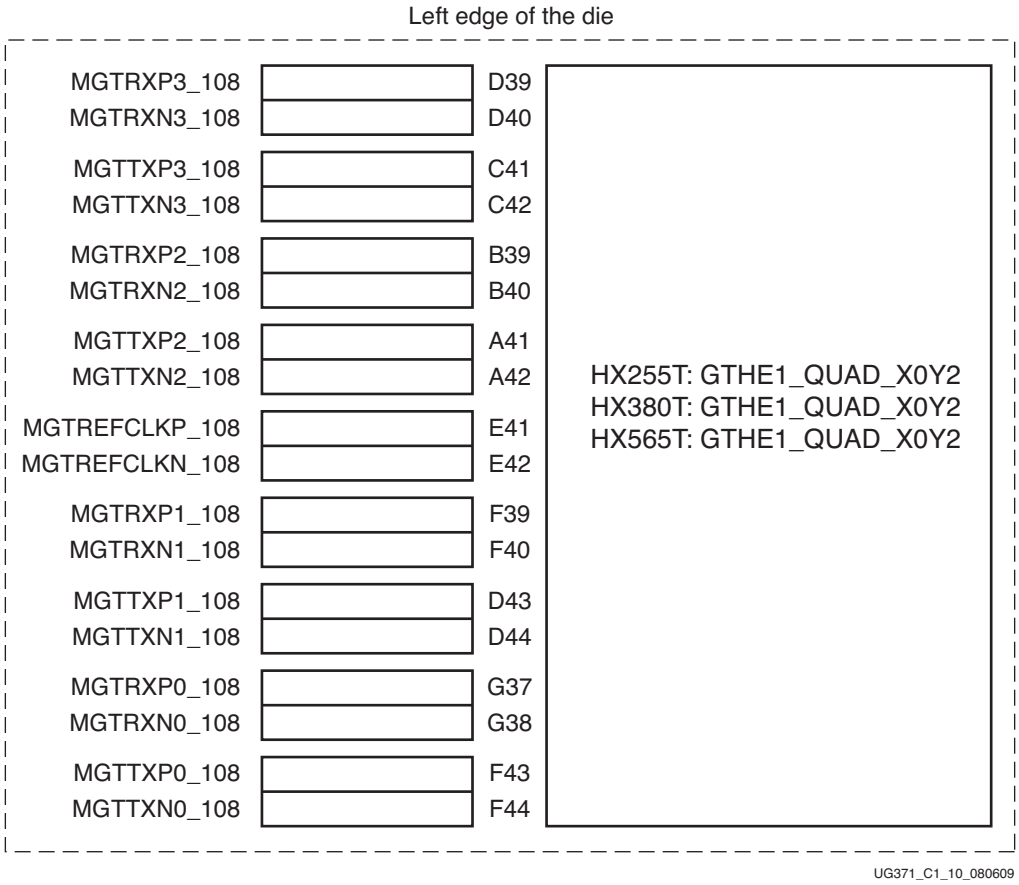

Figure 1-10: **Placement Diagram for the FF1923 and FF1924 Packages (4 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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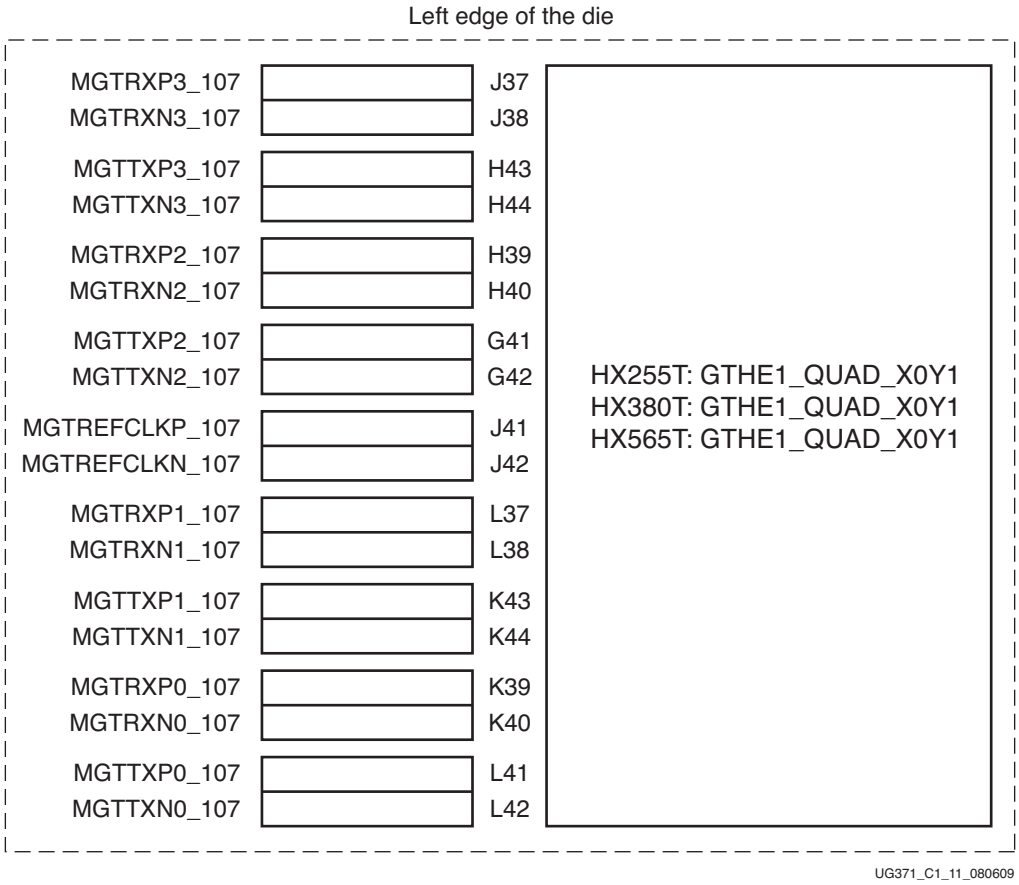

Figure 1-11: **Placement Diagram for the FF1923 and FF1924 Packages (5 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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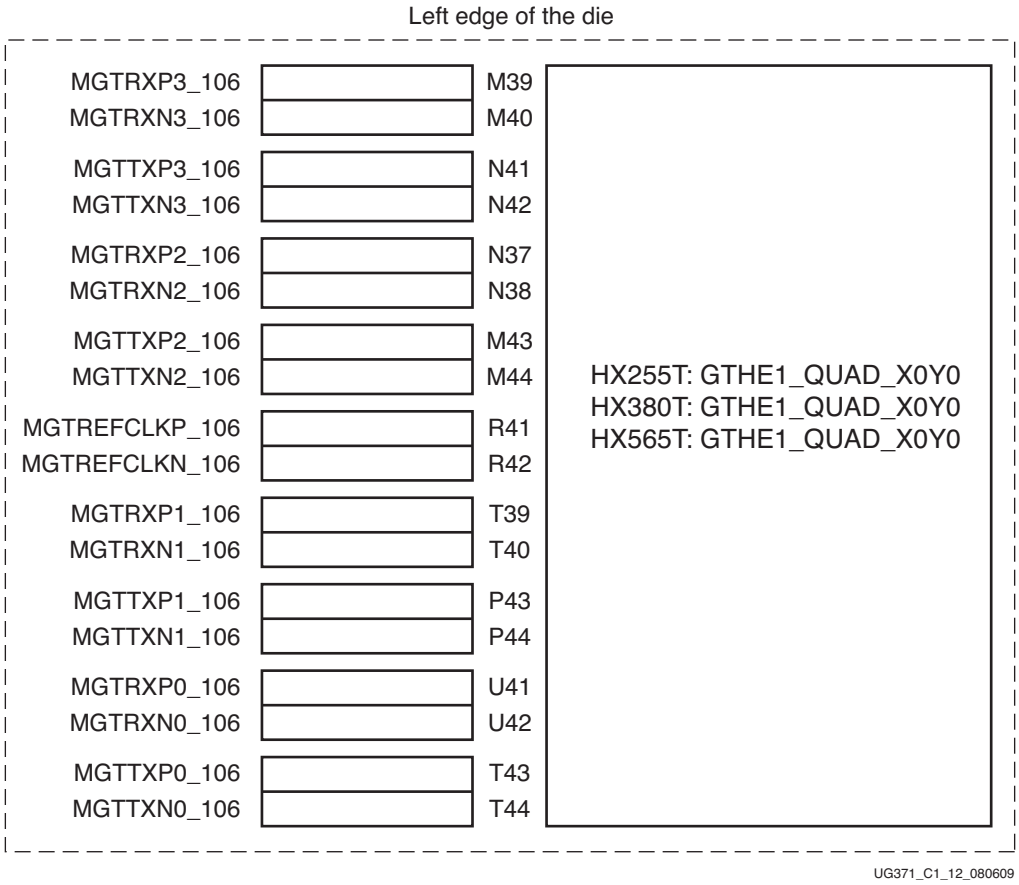

Figure 1-12: **Placement Diagram for the FF1923 and FF1924 Packages (6 of 6)**

Note: The XC6VHX255T device is available only in the FF1923 package.

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Shared Transceiver Features

Reference Clock Input Structure

Functional Description

The reference clock input structure is illustrated in Figure 2-1. The input is terminated internally with 50Ω on each leg to 2/3 MGTHAVCCPLL. The reference clock input is instantiated in software with an IBUFDS_GTHE1 primitive. Its location is fixed via LOC constraints in the UCF. Refer to Implementation, page 31 for details.

The output of the IBUFDS_GTHE1 primitive drives the REFCLK input of the GTHE1_QUAD primitive. The ports and attributes controlling each of the IBUFDS_GTHE1 primitives are mapped to the respective GTHE1_QUAD primitive.

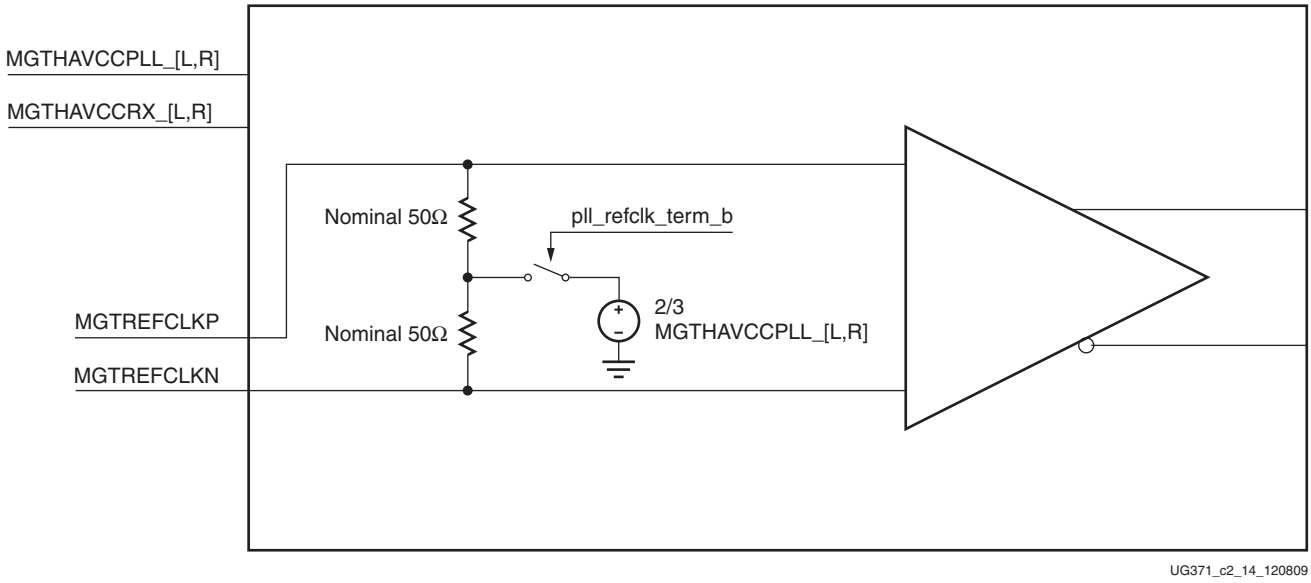

Figure 2-1: **Reference Clock Input Structure**

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Ports and Attributes

Table 2-1 defines the reference clock input structure ports for the GTHE1_QUAD primitive.

Table 2-1: **Reference Clock Input Structure Ports for the GTHE1_QUAD Primitive**

Port	Dir	Clock Domain	Description
REFCLK	In	N/A	REFCLK is an external clock driven by the O port of the IBUFDS_GTHE1 software primitive as the reference clock to the GTHE1_QUAD primitive.

Table 2-2 defines the reference clock input structure ports for the IBUFDS_GTHE1 software primitive.

Table 2-2: **Reference Clock Input Structure Ports for the IBUFDS_GTHE1 Primitive**

Port	Dir	Clock Domain	Description
I	In	Async	This port is the positive input of the reference clock differential pair.
IB	In	Async	This port is the negative input of the reference clock differential pair.
O	Out	Async	This port is the output of the reference clock buffer connected to the REFCLK port of the GTHE1_QUAD primitive.

Table 2-3 defines the reference clock input structure attribute for the GTHE1_QUAD software primitive.

Table 2-3: **Reference Clock Input Structure Attribute**

Attribute	Type	Description
PLL_CFG1	16-bit Binary	This attribute defaults to `16'h81C0`. [15]: REFCLK termination control (pll_refclk_term_b) AC-coupled mode: `1'b1` Reserved: `1'b0` [14:0]: Reserved Reserved: `15'h01C0`

Using the Reference Clock

The reference clock is always used in an AC-coupled mode. The recommended value for the AC-coupling capacitors is 100 nF. The LVPECL clock must be used to drive the reference clock pins. Refer to DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics* for electrical and switching specifications.

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Reference Clock Distribution and Selection

Functional Description

For proper high-speed operation, the GTH transceiver requires a high-quality, low-jitter reference clock. Because of the shared PMA PLL architecture inside the GTH Quad, each reference clock sources all four lanes. The reference clock is used to produce the PLL clock, which is divided by one or four to make individual TX and RX serial clocks and parallel clocks for each GTH transceiver.

The GTH Quad reference clock is provided through the REFCLK port. There are two ways to drive the REFCLK port:

- Using an external oscillator to drive GTH dedicated clock routing
- Using a clock from a neighboring GTH Quad through GTH dedicated clock routing (not recommended for GTH transceivers operating a line rates 2.8 Gb/s and above)

Using the dedicated clock routing provides the best possible clock to the GTH Quad. Each GTH Quad has a dedicated clock pin, represented by the IBUFDS_GTHE1 primitive, that can be used to drive the dedicated clock routing.

This clocking section shows how to select the dedicated clocks for use by one or more GTH Quads.

Ports and Attributes

Table 2-4 defines the reference clock selection ports.

Table 2-4: **Reference Clock Selection Ports**

Port	Dir	Clock Domain	Description
PLLREFCLKSEL[2:0]	In	DCLK	Reserved. Tie these inputs to 000.
REFCLK	In	N/A	This input is the external jitter stable clock driven by the IBUFDS_GTHE1 primitive as the reference clock to the GTHE1_QUAD primitive.
TSTREFCLKFAB	Out	N/A	This port provides direct access to the reference clock provided to the shared PLL in the GTHE1_QUAD primitive. The clock is routed through interconnect and can be used to clock FPGA logic.
TSTREFCLKOUT	Out	N/A	This port provides direct access to the reference clock provided to the shared PLL in the GTHE1_QUAD primitive. The clock is routed through the global clock tree (must be connected through a BUFG) and can be used to clock FPGA logic. This port can also connect directly to an MMCM or BUFR.

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Table 2-5 defines the reference clock selection attributes.

Table 2-5: **Reference Clock Selection Attributes**

Attribute	Type	Description
PLL_CFG2	16-bit Hex	Reserved. Use the recommended values from the Virtex®-6 FPGA GTH Transceiver Wizard.

Clocking from an External Source

Each GTH Quad has a dedicated pin that can be connected to an external clock source. To use these pins, an IBUFDS_GTHE1 primitive is instantiated. In the user constraints file (UCF), the IBUFDS_GTHE1 input pins are constrained to the locations of the dedicated clock pins for the GTH Quad. In the design, the output of the IBUFDS_GTHE1 primitive is connected to the REFCLK input port. The locations of the dedicated pins for all GTH Quads are documented in Implementation, page 31.

Figure 2-2 shows a differential GTH clock pin pair sourced by an external oscillator on the board.

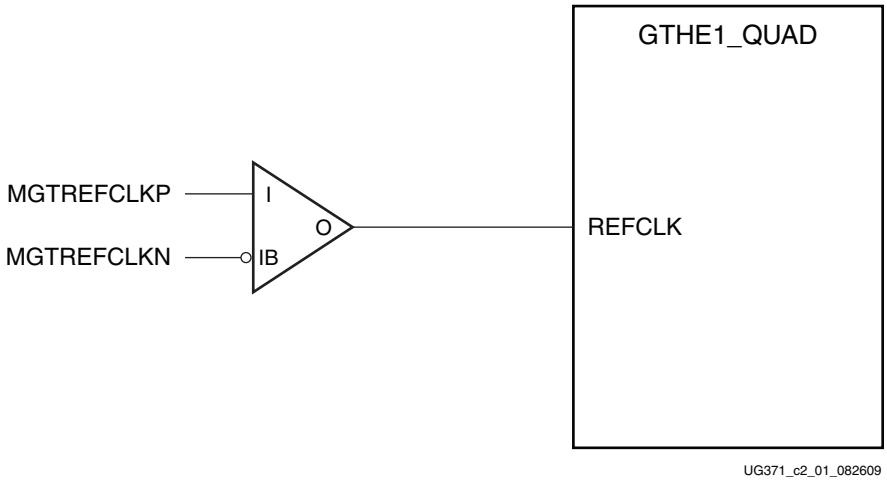

Figure 2-2: **Single GTHE1_QUAD Clocked Externally**

Clocking from a Neighboring GTH Quad

The external reference clock from one GTH Quad can be used to drive the REFCLK input port of the neighboring GTH Quad. The example in Figure 2-3 uses the clock from one GTH Quad to clock one neighbor above and one neighbor below. A GTH Quad shares its clock with its neighbors using the dedicated clock routing resources.

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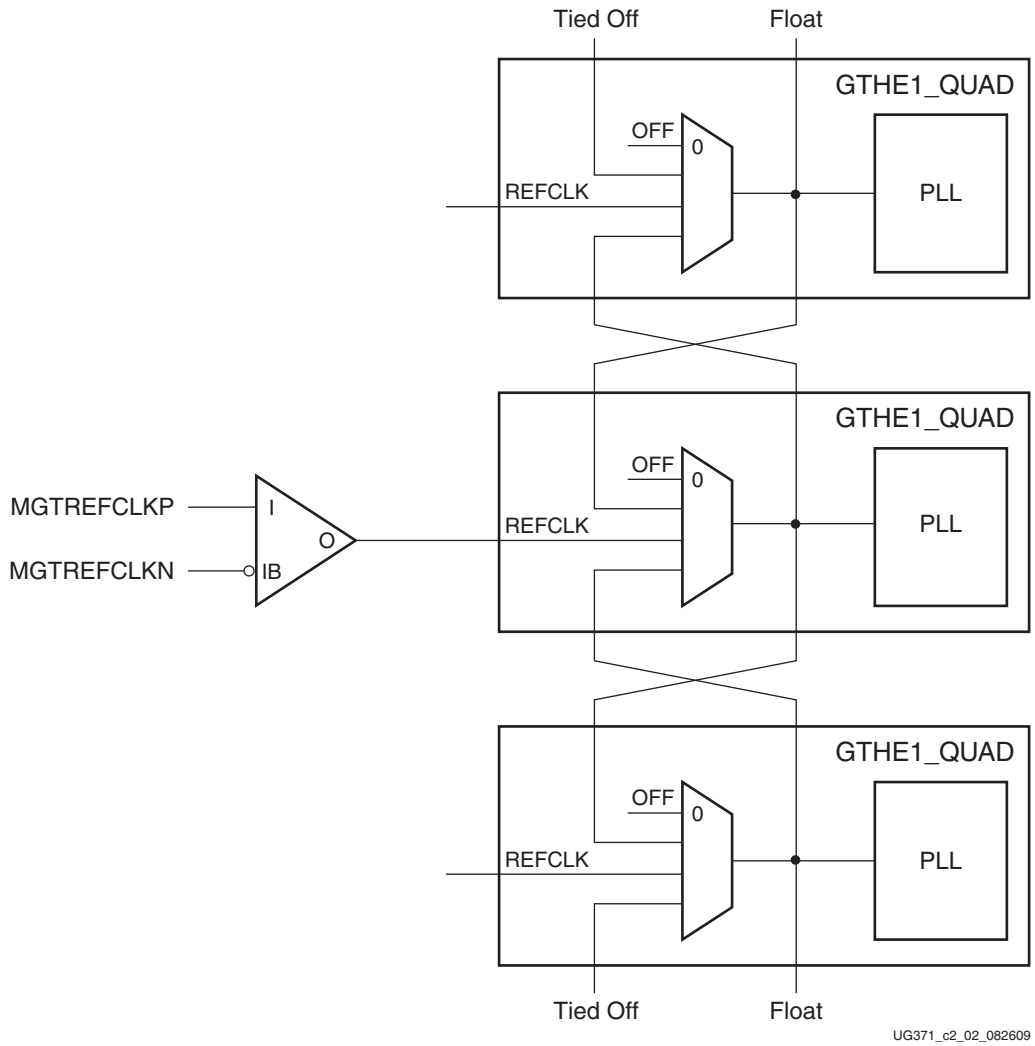

Figure 2-3: **Multiple GTHE1_QUADs with Shared Reference Clock**

These rules must be observed when sharing a reference clock to ensure that jitter margins for high-speed designs are met:

1. The sharing of a reference clock is allowed only for 2.8 Gb/s and below.
2. The external reference clock that drives the REFCLK input port of a given quad (the sourcing GTH Quad) needs to be used by the PLL in the same Quad due to the position of the REFCLK multiplexer.
3. The number of GTH Quads above the sourcing GTH Quad must not exceed one.
4. The number of GTH Quads below the sourcing GTH Quad must not exceed one.
5. The reference clock cannot be routed across the FPGA to the other GTH Quad column.
6. The reference clock cannot be shared with a neighboring GTX transceiver.

The maximum number of GTH transceivers that can be sourced by a single clock pin pair is 12.

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PLL

Functional Description

Each GTHE1_QUAD primitive has one PLL block that is shared between the four lanes within the Quad. Each lane in the GTH Quad has separate dividers for the transmitter and the receiver, which allow each transmitter and receiver to operate in different divided-down line rates based on the VCO frequency. The PLL in one GTHE1_QUAD primitive cannot be shared with another GTH Quad.

The PLL has an operating range from 4.96 GHz to 5.591 GHz with the lane divider, which can divide the output of the PLL by one or four. Table 2-6 shows the supported line rate and PLL settings in the GTH transceiver.

Table 2-6: **Supported Line Rates per TX and RX Lane Divider Settings**

TX and RX PLL Lane Divider	Line Rate Range (Gb/s)
1	9.920 – 11.182
2	4.96 - 5.591
4	2.48 – 2.795
8	1.24 to 1.397

Figure 2-4 illustrates the PLL architecture. A low phase noise PLL input clock is recommended for optimal jitter performance. The feedback divider determines the VCO multiplication and the PLL output frequency.

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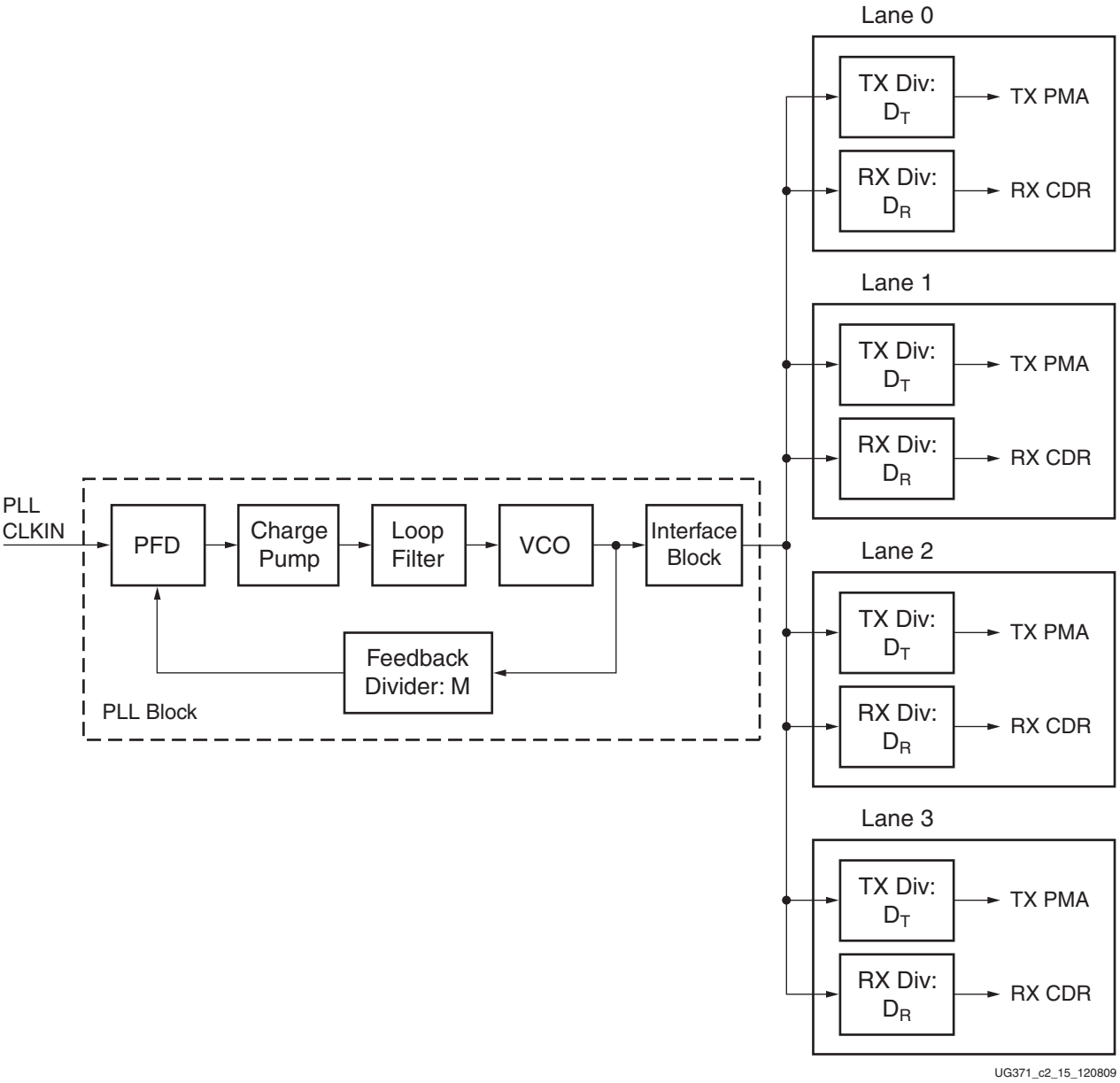

Figure 2-4: **PLL Block Diagram**

The feedback divider value (M), part of the PLL_CFG0 attribute, is set by the Virtex-6 FPGA GTH Transceiver Wizard. The TX output lane divider (D_T) is set by the TXRATE port, and the RX output lane divider (D_R) is set by the RXRATE ports.

Equation 2-1 shows how to determine the TX line rate (Gb/s).

$$f_{TX_LineRate} = f_{PLLClkin} \times \frac{M}{D_T} \quad \text{Equation 2-1}$$

Equation 2-2 shows how to determine the RX line rate (Gb/s).

$$f_{RX_LineRate} = f_{PLLClkin} \times \frac{M}{D_R} \quad \text{Equation 2-2}$$

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The PLL output clock is used to generate the PCS clocks. There are three dividers to generate different PCS clocks (see Figure 2-5):

- PLLPCSCLKDIV
- SAMPLERATE
- TX_FABRIC_WIDTH<n>/RX_FABRIC_WIDTH<n>

Figure 2-5 shows the relationship between the dividers in the PCS block. The PLLPCSCLKDIV ports determines the PCS clock frequency common across all the lanes in the Quad. The SAMPLERATE port divides the Quad PCS clock and determine the internal lane PCS clock for the each lane. The TX_FABRIC_WIDTH<n>/RX_FABRIC_WIDTH<n> attributes need to have correct values to get the correct TXUSERCLKOUT and RXUSERCLKOUT values, depending on the ratio between the FPGA logic data bus width and internal data bus width.

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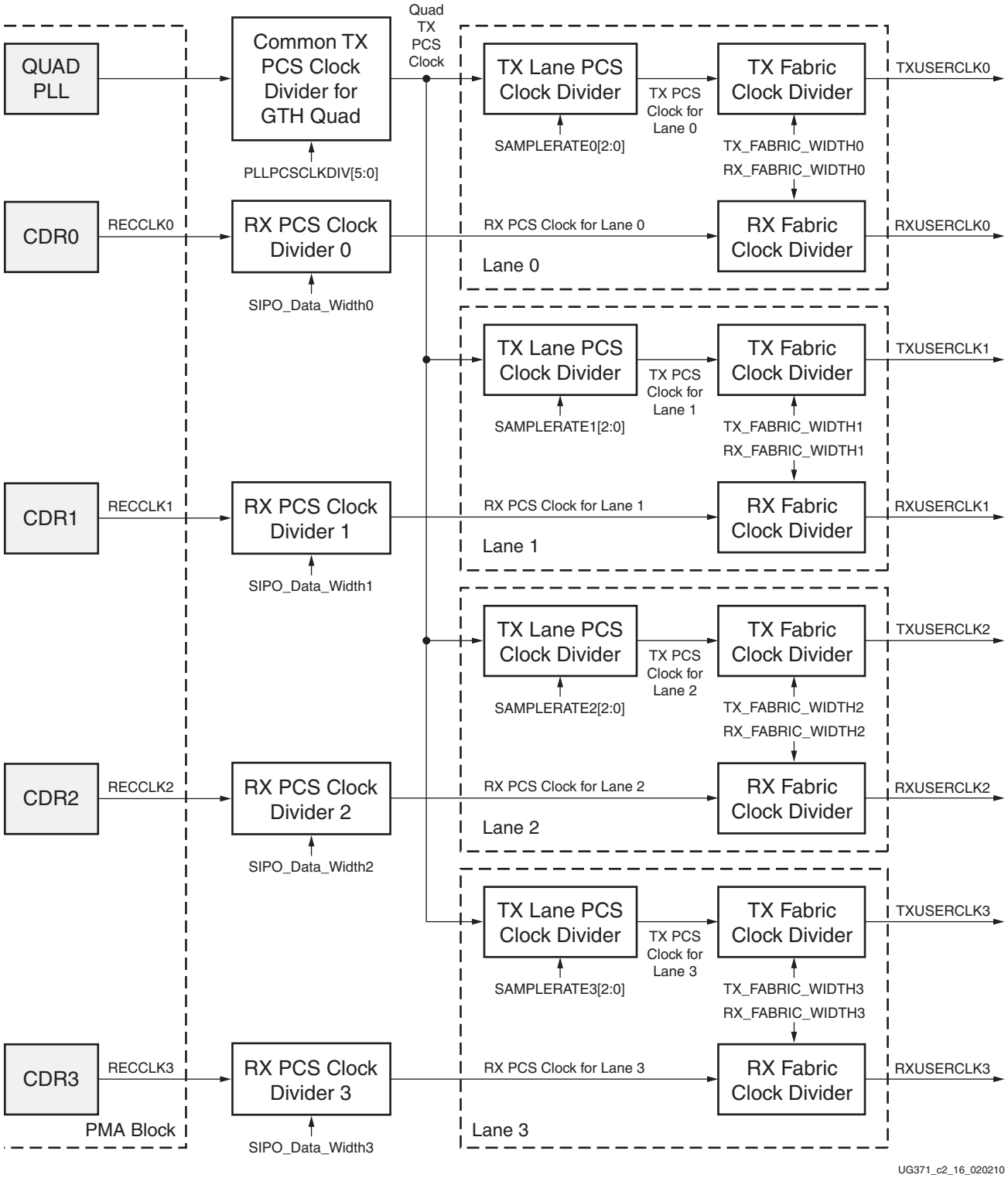

Figure 2-5: **TX and RX Parallel Clock Dividers in the PCS Block**

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Ports and Attributes

Table 2-7 defines the PLL ports.

Table 2-7: **PLL Ports**

Port	Dir	Clock Domain	Description
GTHINIT	In	DCLK	This input triggers the programming of the attributes setting from configuration memory to the registers in the GTHE1_QUAD primitive. This port must be asserted for 1 DCLK clock cycle.
GTHINITDONE	Out	DCLK	This port goes High when the process of programming the bits from the configuration memory to the registers in the GTHE1_QUAD primitive is completed. This output is driven Low when GTHRESET or GTHINIT is asserted. It remains Low until after the assertion of GTHINIT.
GTHRESET	In	DCLK	This port resets the GTHE1_QUAD primitive. When this port is asserted, the configuration of all GTH transceivers within the GTHE1_QUAD primitive reverts to the default setting of 10GBASE-R. To maintain the same user configuration, GTHINIT must be pulsed after GTHRESET is deasserted. This port must be asserted for 20 DCLK clock cycles.
PLLPCSCLKDIV[5:0]	In	DCLK	PLL output divider for the GTH Quad PCS clock. This port specifies the divider for the PCS clock frequency. It must be set to N – 1 to achieve an N division of the PLL clock frequency.
RXCTRLACK0 RXCTRLACK1 RXCTRLACK2 RXCTRLACK3	Out	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	Assertion of this acknowledgment signal indicates completion of a change event on RXRATE<n> and RXPOWERDOWN<n>. The state of this port is valid only after GTHINITDONE is driven High and TXUSERCLKIN<n> is stable. This port is not asserted until all internal clocks for the RX datapath, including the PLL output clock, are stable.

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Table 2-7: **PLL Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXRATE0[1:0] RXRATE1[1:0] RXRATE2[1:0] RXRATE3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the receiver lane divider values: `00`: Full data rate `01`: 1/2 data rate `10`: 1/4 data rate `11`: 1/8 data rate This port is active after the TX side becomes active. TXUSERCLKIN<n> must be stable to use this port. This port must always be set to `2'b00` during initialization and when GTHRESET is asserted.
SAMPLERATE0[2:0] SAMPLERATE1[2:0] SAMPLERATE2[2:0] SAMPLERATE3[2:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the frequency of the strobe signal relative to the internal transmitter PCS clock after the transmitter lane dividers: Strobe frequency: PCS clock frequency = 1:1 – SAMPLERATE = `3'b000` 1:2 – SAMPLERATE = `3'b001` 1:4 – SAMPLERATE = `3'b010` 1:8 – SAMPLERATE = `3'b011` When PCS_MODE_LANE<n>[3:0] = `4'b1010` (16-bit raw) and TX_FABRIC_WIDTH = 16, SAMPLERATE is tied to `3'b000`. Otherwise, SAMPLERATE[2] = `1'b0` and SAMPLERATE[1:0] = TXRATE. This port must always be set to `3'b000` during initialization and when GTHRESET is asserted.
TXCTRLACK0 TXCTRLACK1 TXCTRLACK2 TXCTRLACK3	Out	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	Assertion of this acknowledgment signal indicates completion of a change event on TXRATE<n>, SAMPLERATE<n>, and TXPOWERDOWN<n>. The state of this port is valid only after GTHINITDONE is driven High and TXUSERCLKIN<n> is stable. This port is not asserted until all internal clocks for the TX datapath, including the PLL output clock, are stable.

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Table 2-7: **PLL Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
TXRATE0[1:0] TXRATE1[1:0] TXRATE2[1:0] TXRATE3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the transmitter lane divider values: `00`: Full data rate `01`: 1/2 data rate `10`: 1/4 data rate `11`: 1/8 data rate This port must always be set to `2'b00` during initialization and when GTHRESET is asserted.

Table 2-8 defines the PLL attributes.

Table 2-8: **PLL Attributes**

Attribute	Type	Description
DLL_CFG0	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
DLL_CFG1	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
PLL_CFG0	16-bit Hex	Reserved. [15:6]: Tie to `10'b1001111111` [5:0]: PLL feedback divider
PLL_CFG1	16-bit Hex	Reserved. Tie to `16'h81C0`
PLL_CFG2	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
RX_FABRIC_WIDTH0 RX_FABRIC_WIDTH1 RX_FABRIC_WIDTH2 RX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the receiver. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bit "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bit "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bit "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bit "6466" (DRP value `3'b111`): 64B/66B mode

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Table 2-8: **PLL Attributes *(Cont'd)***

Attribute	Type	Description
TX_FABRIC_WIDTH0 TX_FABRIC_WIDTH1 TX_FABRIC_WIDTH2 TX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the transmitter. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bit "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bit "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bit "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bit "6466" (DRP value `3'b111`): 64B/66B mode

PLL Settings for the Common Protocol

Table 2-9 shows example PLL divider settings for several standard protocols that the GTH transceiver supports.

Table 2-9: **PLL Divider Settings for Common Protocols**

Protocol	Line Rate [Gb/s]	REFCLK [MHz]	PLL Feedback Divider PLL_CFG0[5:0] (N – 1)	PLL Freq [GHz]	TXRATE RXRATE	PLLPCSCLKDIV (N – 1)	Quad PCS Clock [MHz]	SAMPLE RATE	Lane PCS Clock	TX_FABRIC_WIDTH RX_FABRIC_WIDTH (Note 1)	TXUSERCLK RXUSERCLK
10GBASE-KR	10.3125	156.25	32	5.15625	`2'b00`	32	156.25	`3'b000`	156.25	`3'b111`	156.25
CEI11	11.096	173.37	31	5.54784	`2'b00`	7	693.75	`3'b000`	693.75	`3'b010`	173.44
OC-192	9.953	155.52	31	4.9765	`2'b00`	7	622.06	`3'b000`	622.06	`3'b010`	155.52
	9.953	311.03	15	4.9765	`2'b00`	7	622.06	`3'b000`	622.06	`3'b010`	155.52
	9.953	622.06	7	4.9765	`2'b00`	7	622.06	`3'b000`	622.06	`3'b010`	155.52
OC-48	2.488	155.52	31	4.976	`2'b10`	31(2)	622.06	`3'b000`(2)	155.5	`3'b000`	155.5
	2.488	311.03	15	4.976	`2'b10`	31(2)	622.06	`3'b000`(2)	155.5	`3'b000`	155.5
	2.488	622.06	7	4.976	`2'b10`	31(2)	622.06	`3'b000`(2)	155.5	`3'b000`	155.5
OTU1	2.677	166.69	31	5.334	`2'b10`	31(2)	666.75	`3'b000`(2)	166.69	`3'b000`	166.69
	2.677	666.75	7	5.334	`2'b10`	31(2)	666.75	`3'b000`(2)	166.69	`3'b000`	166.69
OTU2	10.709	167.33	31	5.35456	`2'b00`	7	669.31	`3'b000`	669.31	`3'b010`	167.33
	10.709	669.31	7	5.35504	`2'b00`	7	669.31	`3'b000`	669.31	`3'b010`	167.33
OTU3	10.7546	168.05	31	5.3773	`2'b00`	7	672.16	`3'b000`	672.16	`3'b010`	168.04
OTU4	11.18	174.69	31	5.590	`2'b00`	7	698.75	`3'b000`	698.75	`3'b010`	174.69
XFP	9.953	155.52	31	4.9765	`2'b00`	7	622.07	`3'b000`	622.07	`3'b010`	155.52
XLAUI	10.3125	156.25	32	5.15625	`2'b00`	32	156.25	`3'b000`	156.25	`3'b101`	257.81
CAUI	10.3125	156.25	32	5.15625	`2'b00`	32	156.25	`3'b000`	156.25	`3'b101`	257.81

Notes:

1. The settings for the TX_FABRIC_WIDTH and RX_FABRIC_WIDTH listed in this table are examples. The settings depend on the external data width that the user selects for the fabric logic.
2. The settings of `3'b000` for SAMPLERATE and 31 for PLLPCSCLKDIV are applicable only when TX/RX_FABRIC_WIDTH are set to `3'b000` (or 16). For higher settings of TX/RX_FABRIC_WIDTH, use `3'b010` for SAMPLERATE and 7 for PLLPCSCLKDIV.

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Reset and Initialization

Functional Description

The different ways to reset the GTH Quad are:

1. Power-up and configure the FPGA.
2. Apply a reset sequence to the GTHRESET and GTHINIT ports.
3. Reset the PCS logic using the power-down ports.

All these methods are described in this section.

These items must be considered to initialize the GTH Quad properly:

- DCLK must always be provided to the GTHE1_QUAD primitive even if the DRP or management interface is not used.

  Note: DCLK *must* be sourced from a free-running clock. It cannot be sourced from TSTREFCLKOUT or TSTREFCLKFAB of the GTH Quad.
- Asserting GTHRESET not only resets the GTH Quad but also changes its configuration back to its default of 10GBASE-R. For example, if the design is configured for OC-192, asserting GTHRESET changes the configuration to 10GBASE-R.
- To keep the user configuration after GTHRESET is deasserted, GTHINIT must be pulsed.
- Both TXUSERCLKIN<n> and RXUSERCLKIN<n> clocks must be stable when TXPOWERDOWN<n> and RXPOWERDOWN<n> are set in normal operation mode.
- The PCS_MODE_LANE<n>, PCS_RESET_LANE<n>, and PCS_RESET_1_LANE<n> attributes must be set to the datapath mode configuration used in the application.

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Ports and Attributes

Table 2-10 defines the reset ports.

Table 2-10: **Reset Ports**

Port	Dir	Clock Domain	Description
DCLK	In	N/A	This input is the DRP interface clock. It is also used as the management interface clock when the management interface is enabled. This clock must be connected and available all the time for the GTHE1_QUAD primitive to initialize properly, even if the DRP or the management interface is not used in the design.
GTHINIT	In	DCLK	This input triggers the programming of the attributes setting from configuration memory to the registers in the GTHE1_QUAD primitive. This port must be asserted for 1 DCLK clock cycle.
GTHINITDONE	Out	DCLK	This port is driven High upon completion of programming the bits from the configuration memory to the registers in the GTHE1_QUAD primitive. This output is driven Low when GTHRESET or GTHINIT is asserted. It remains Low until after the assertion of GTHINIT.
GTHRESET	In	DCLK	This port resets the GTHE1_QUAD primitive. When this port is asserted, the configuration of all GTH transceivers within the GTHE1_QUAD primitive reverts to the default setting of 10GBASE-R. To maintain the same user configuration, GTHINIT must be pulsed after GTHRESET is deasserted. This port must be asserted for 20 DCLK clock cycles.
RXBUFRESET0 RXBUFRESET1 RXBUFRESET2 RXBUFRESET3	In	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This input resets the buffer inside the RX data converter (see Figure 4-5, page 138). Both the internal RX clock and RXUSERCLKIN<n>(1) must be stable before a reset can be applied to the buffer.
RXCTRLACK0 RXCTRLACK1 RXCTRLACK2 RXCTRLACK3	Out	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	Assertion of this acknowledgment signal indicates completion of a change event on RXRATE<n> and RXPOWERDOWN<n>. The state of this port is valid only after GTHINITDONE is driven High and TXUSERCLKIN<n> is stable.
RXPOWERDOWN0[1:0] RXPOWERDOWN1[1:0] RXPOWERDOWN2[1:0] RXPOWERDOWN3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal requests the receiver power state: `00`: Normal operation. `10`: Power off receiver logic. The PLL continues to operate in this state. This port must always be set to `2'b10` during initialization and when GTHRESET is asserted. If the Quad is configured as a x4 link, only the port from Lane 0 is valid.

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Table 2-10: **Reset Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXRATE0[1:0] RXRATE1[1:0] RXRATE2[1:0] RXRATE3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the receiver lane divider values: `00`: Full data rate `01`: 1/2 data rate `10`: 1/4 data rate `11`: 1/8 data rate This port is active after the TX side becomes active. TXUSERCLKIN<n> must be stable to use this port. This port must always be set to `2'b00` during initialization and when GTHRESET is asserted.
RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	In	N/A	This port provides a clock for the internal receiver PCS datapath. It is a buffered version of RXUSERCLKOUT<n>.
SAMPLERATE0[2:0] SAMPLERATE1[2:0] SAMPLERATE2[2:0] SAMPLERATE3[2:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the frequency of the strobe signal relative to the internal transmitter PCS clock after the transmitter lane dividers: Strobe frequency: PCS clock frequency = 1:1 – SAMPLERATE = `3'b000` 1:2 – SAMPLERATE = `3'b001` 1:4 – SAMPLERATE = `3'b010` 1:8 – SAMPLERATE = `3'b011` When PCS_MODE_LANE<n>[3:0] = `4'b1010` (16-bit raw) and TX_FABRIC_WIDTH = 16, SAMPLERATE is tied to `3'b000`. Otherwise, SAMPLERATE[2] = `1'b0` and SAMPLERATE[1:0] = TXRATE. This port must always be set to `3'b000` during initialization and when GTHRESET is asserted.
TXBUFRESET0 TXBUFRESET1 TXBUFRESET2 TXBUFRESET3	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This input resets the buffer inside the TX data converter (see Figure 3-2, page 83). Both the internal TX clock and TXUSERCLKIN<n> must be stable before a reset can be applied to the buffer.
TXCTRLACK0 TXCTRLACK1 TXCTRLACK2 TXCTRLACK3	Out	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This acknowledgment signal indicates completion of a change event on TXRATE<n>, SAMPLERATE<n>, and TXPOWERDOWN<n>. The state of this port is valid only after the GTHINITDONE is driven High and TXUSERCLKIN<n> is stable.

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Table 2-10: **Reset Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
TXPOWERDOWN0[1:0] TXPOWERDOWN1[1:0] TXPOWERDOWN2[1:0] TXPOWERDOWN3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal requests the transmitter power state: `00`: Normal operation `10`: Power off transmitter logic. The PLL continues to operate in this state. This port must always be set to `2'b10` during initialization and when GTHRESET is asserted. If the Quad is configured as a x4 link, only the port from Lane 0 is valid.
TXRATE0[1:0] TXRATE1[1:0] TXRATE2[1:0] TXRATE3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal specifies the transmitter lane divider values: `00`: Full data rate `01`: 1/2 data rate `10`: 1/4 data rate `11`: 1/8 data rate This port must always be set to `2'b00` during initialization and when GTHRESET is asserted.
TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	In	N/A	This port provides a clock for the internal transmitter PCS datapath. It is a buffered version of the TXUSERCLKOUT<n>. This clock must be stable for RXCTRLACK<n> and RXRATE<n> ports to be active.

Notes:

1. <n> denotes lane 0, 1, 2, or 3.

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Table 2-11 defines the reset attributes.

Table 2-11: **Reset Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 2-11: **Reset Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. These bits vary by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX Raw FIFO [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset 8B/10B TX FIFO [1]: Reset RX loopback FIFO [0]: Reset 64B/66B and PRBS TX FIFO
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: These bits control the datapath resets. They vary by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
LANE_PWR_CTRL_LANE0 LANE_PWR_CTRL_LANE1 LANE_PWR_CTRL_LANE2 LANE_PWR_CTRL_LANE3	16-bit Hex	Reserved. Tie to `16'h0400`.
RX_CFG1_LANE0 RX_CFG1_LANE1 RX_CFG1_LANE2 RX_CFG1_LANE3	16-bit Hex	Reserved. Tie to `16'h821F`.
RX_CFG0_LANE0 RX_CFG0_LANE1 RX_CFG0_LANE2 RX_CFG0_LANE3	16-bit Hex	Reserved. Tie to `16'h0500`.
MISC_CFG	16-bit Hex	Reserved. Tie to `16'h0008`.
TX_CLK_SEL1_LANE0 TX_CLK_SEL1_LANE1 TX_CLK_SEL1_LANE2 TX_CLK_SEL1_LANE3	16-bit Hex	Reserved. Tie to `16'h2121`.

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GTH Quad Initialization in Response to Completion of Configuration

Figure 2-6 shows the initialization sequence of the GTH Quad following completion of configuration when the GTH transceiver is configured in full line rate mode (i.e., TXRATE<n>[1:0], SAMPLERATE<n>[2:0], and RXRATE<n>[1:0] ports are set to all zeros).

To initialize the GTH transceiver when configured in full line rate mode:

1. Set PCS_MODE_LANE<n>[7:4] and PCS_MODE_LANE<n>[3:0] to the datapath mode used in the application for RX and TX, respectively.
2. Set PCS_RESET_LANE<n> to the datapath mode used in the application.
3. Set PCS_RESET_1_LANE<n> to the datapath mode used in the application.
4. Set TXPOWERDOWN<n>[1:0] and RXPOWERDOWN<n>[1:0] to `2'b10`.
5. After completion of configuration (GSR going High), wait for GTHINITDONE to go High. The PLL is locked after GTHINITDONE is asserted.
6. Pulse TXBUFRESET for one TXUSERCLKIN clock cycle.
7. Change TXPOWERDOWN<n>[1:0] to `2'b00` to power up the transmitter logic.
8. Wait for TXCTRLACK<n> to go High. The transmitter is ready for normal operation.
9. Change RXPOWERDOWN<n>[1:0] to `2'b00`.
10. Wait for RXCTRLACK<n> to go High.
11. Pulse RXBUFRESET for one RXUSERCLKIN clock cycle. The receiver is ready for normal operation.

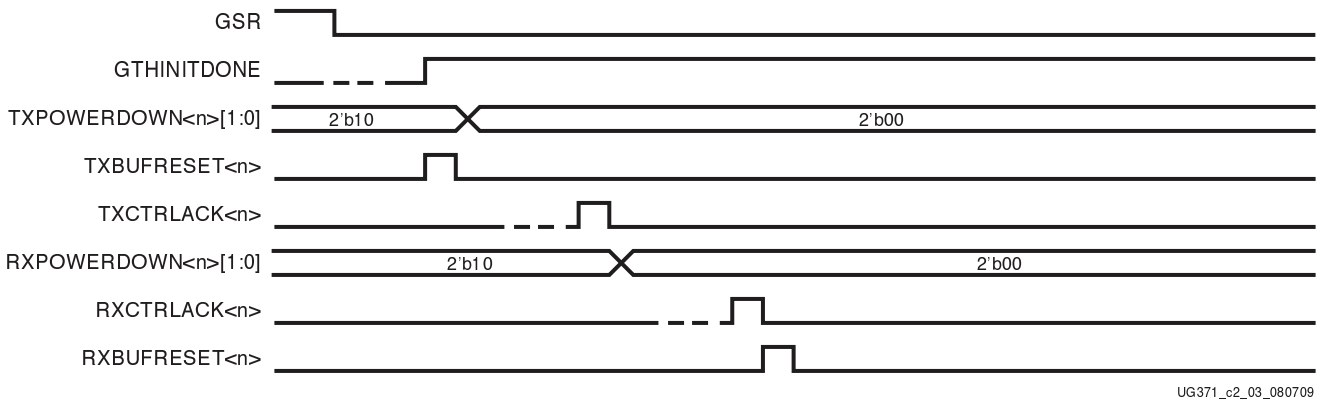

Figure 2-6: **GTH Transceiver Initialization when in Full Line Rate Mode**

Note relevant to Figure 2-6:

1. The TXCTRLACK<n> and RXCTRLACK<n> signals can be High for more than 1 DCLK clock cycle.

Figure 2-7 shows the initialization sequence of the GTH Quad following completion of configuration when the GTH transceiver is configured in divided line rate mode (i.e., TXRATE<n>[1:0], SAMPLERATE<n>[2:0], and RXRATE<n>[1:0] ports are set to non-zero values).

To initialize the GTH transceiver when configured in divided line rate mode:

1. Set PCS_MODE_LANE<n>[7:4] and PCS_MODE_LANE<n>[3:0] to the datapath mode used in the application for RX and TX, respectively.
2. Set PCS_RESET_LANE<n> to the datapath mode used in the application.

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3. Set PCS_RESET_1_LANE<n> to the datapath mode used in the application.
4. Set TXPOWERDOWN<n>[1:0] and RXPOWERDOWN<n>[1:0] to `2'b10`.
5. Set TXRATE<n>[1:0] and RXRATE<n>[1:0] to `2'b00`, and set SAMPLERATE<n>[2:0] to `3'b000`.
6. After completion of configuration (GSR going High), wait for GTHINITDONE to go High. The PLL is locked after GTHINITDONE is asserted.
7. Change TXRATE<n>[1:0] to the value used for the application and wait for TXCTRLACK to go High.
8. Change SAMPLERATE<n>[2:0] to the value used for the application and wait for TXCTRLACK to go High.
9. Pulse TXBUFRESET for one TXUSERCLKIN clock cycle.
10. Change TXPOWERDOWN<n>[1:0] to `2'b00` to power up the transmitter logic.
11. Wait for TXCTRLACK<n> to go High. The transmitter is ready for normal operation.
12. Change RXRATE<n>[1:0] to the value used for the application and wait for RXCTRLACK to go High.
13. Change RXPOWERDOWN<n>[1:0] to `2'b00`.
14. Wait for RXCTRLACK<n> to go High.
15. Pulse RXBUFRESET for one RXUSERCLKIN clock cycle. The receiver is ready for normal operation.

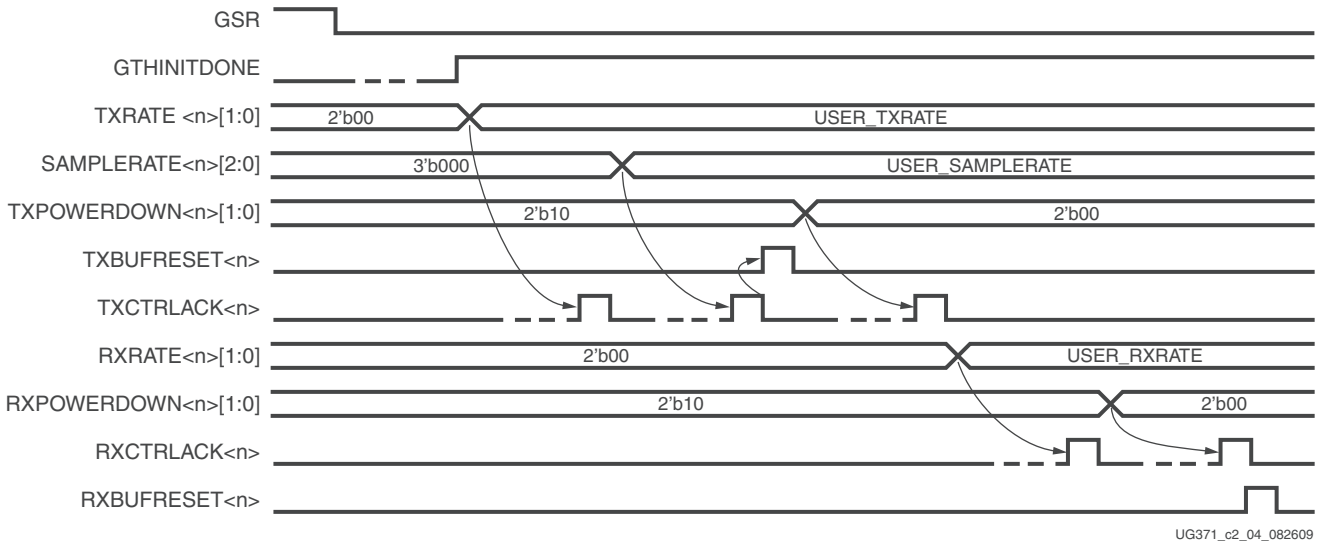

Figure 2-7: **GTH Transceiver Initialization when in Divided Line Rate Mode**

Note relevant to Figure 2-7:

1. The TXCTRLACK<n> and RXCTRLACK<n> signals can be High for more than 1 DCLK clock cycle.

GTH Quad Reset in Response to GTHRESET

GTHRESET is used as a reset to all four GTH lanes within the Quad, including the PLL. Besides resetting the GTH Quad, GTHRESET also changes the Quad to its default configuration of 10GBASE-R. If the GTH Quad has a different configuration from the

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default of 10GBASE-R, the design must also assert GTHINIT after GTHRESET is deasserted.

Figure 2-8 shows the reset sequence of the GTH Quad following the assertion of GTHRESET when the GTH transceiver is configured in full line rate mode (i.e., the TXRATE<n>[1:0], SAMPLERATE<n>[2:0], and RXRATE<n>[1:0] ports are set to all zeros).

To reset the GTH transceiver when configured in full line rate mode:

1. Set PCS_MODE_LANE<n>[7:4] and PCS_MODE_LANE<n>[3:0] to the datapath mode used in the application for RX and TX, respectively.
2. Set PCS_RESET_LANE<n> to the datapath mode used in the application.
3. Set PCS_RESET_1_LANE<n> to the datapath mode used in the application.
4. Set TXPOWERDOWN<n>[1:0] and RXPOWERDOWN<n>[1:0] to `2'b10`.
5. Assert GTHRESET for 20 DCLK clock cycles. The TXCTRLACK<n> and RXCTRLACK<n> ports from all four lanes are asserted.
6. Wait for TXCTRLACK<n> and RXCTRLACK<n> from all four lanes to be deasserted and then assert GTHINIT for 1 DCLK clock cycle.
7. Wait for GTHINITDONE to go High. The PLL is locked after GTHINITDONE is asserted.
8. Pulse TXBUFRESET for one TXUSERCLKIN clock cycle.
9. Change TXPOWERDOWN<n>[1:0] to `2'b00` to power up the transmitter logic.
10. Wait for TXCTRLACK<n> to go High. The transmitter is ready for normal operation.
11. Change RXPOWERDOWN<n>[1:0] to `2'b00`.
12. Wait for RXCTRLACK<n> to go High.
13. Pulse RXBUFRESET for one RXUSERCLKIN clock cycle. The receiver is ready for normal operation.

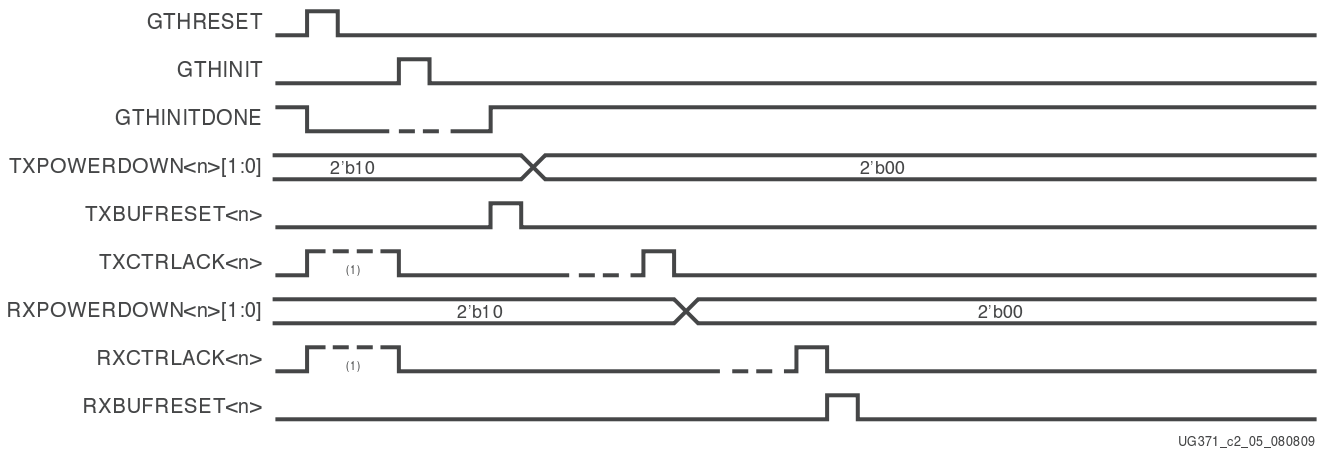

Figure 2-8: **GTH Transceiver Reset when in Full Line Rate Mode**

Notes relevant to Figure 2-8:

1. The TXCTRLACK<n> and RXCTRLACK<n> signals at this time refer to all four lanes within the Quad. The user must wait for all four TXCTRLACK<n> and RXCTRLACK<n> signals to be deasserted before asserting GTHINIT.
2. The TXCTRLACK<n> and RXCTRLACK<n> signals can be High for more than 1 DCLK clock cycle.

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Figure 2-9 shows the reset sequence of the GTH Quad following the assertion of GTHRESET when the GTH transceiver is configured in divided line rate mode (i.e., the TXRATE<n>[1:0], SAMPLERATE<n>[2:0], and RXRATE<n>[1:0] ports are set to non-zero values).

To initialize the GTH transceiver when configured in divided line rate mode:

1. Set PCS_MODE_LANE<n>[7:4] and PCS_MODE_LANE<n>[3:0] to the datapath mode used in the application for RX and TX, respectively.
2. Set PCS_RESET_LANE<n> to the datapath mode used in the application.
3. Set PCS_RESET_1_LANE<n> to the datapath mode used in the application.
4. Set TXPOWERDOWN<n>[1:0] and RXPOWERDOWN<n>[1:0] to `2'b10`.
5. Set TXRATE<n>[1:0] and RXRATE<n>[1:0] to `2'b00`, and set SAMPLERATE<n>[2:0] to `3'b000`.
6. Assert GTHRESET for 20 DCLK clock cycles. TXCTRLACK<n> and RXCTRLACK<n> from all four lanes are asserted.
7. Wait for TXCTRLACK<n> and RXCTRLACK<n> from all four lanes to be deasserted and then assert GTHINIT for 1 DCLK clock cycle.
8. Wait for GTHINITDONE to go High. The PLL is locked after GTHINITDONE is asserted.
9. Change TXRATE<n>[1:0] to the value used for the application and wait for TXCTRLACK to go High.
10. Change SAMPLERATE<n>[2:0] to the value used for the application and wait for TXCTRLACK to go High.
11. Pulse TXBUFRESET for one TXUSERCLKIN clock cycle.
12. Change TXPOWERDOWN<n>[1:0] to `2'b00` to power up the transmitter logic.
13. Wait for TXCTRLACK<n> to go High. The transmitter is ready for normal operation.
14. Change RXRATE<n>[1:0] to the value used for the application and wait for RXCTRLACK signal to go High.
15. Change RXPOWERDOWN<n>[1:0] to `2'b00`.
16. Wait for RXCTRLACK<n> to go High.
17. Pulse RXBUFRESET for one RXUSERCLKIN clock cycle. The receiver is ready for normal operation.

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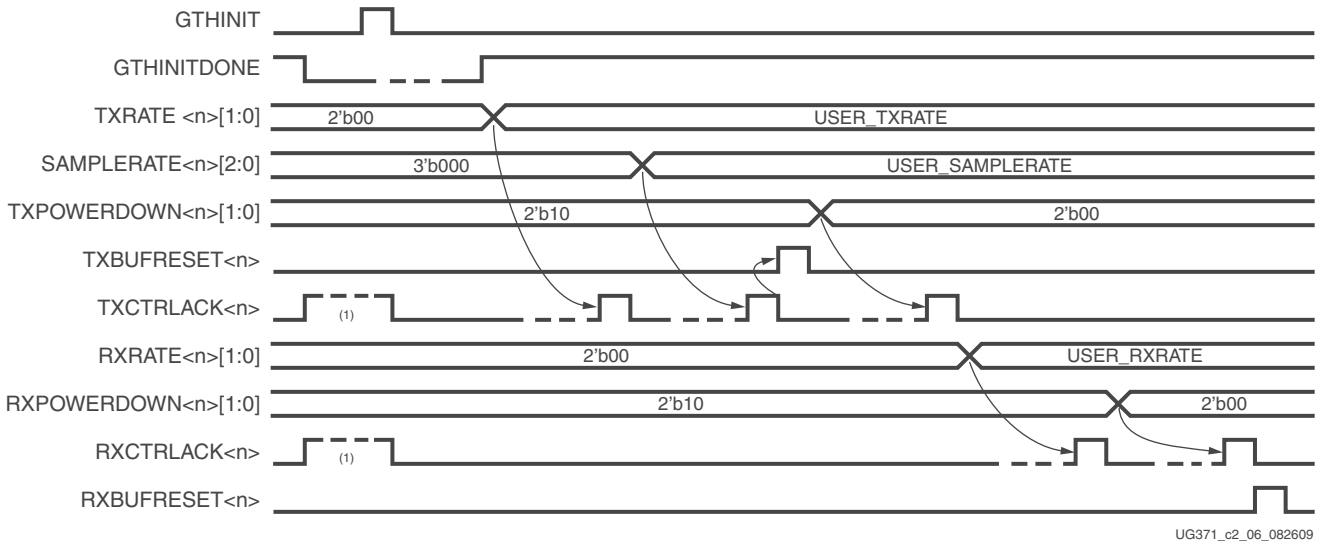

Figure 2-9: **GTH Transceiver Reset when in Divided Line Rate Mode**

Notes relevant to Figure 2-9:

1. TXCTRLACK<n> and RXCTRLACK<n> at this time refers to all four lanes within the Quad. The user must wait for all four TXCTRLACK<n> and RXCTRLACK<n> signals to be deasserted before asserting GTHINIT.
2. The TXCTRLACK<n> and RXCTRLACK<n> signals can be High for more than 1 DCLK clock cycle.

Resetting the Transmit Datapath

The transmit datapath of the GTH transceiver must be reset under these conditions:

- After a line rate change
- When the clock going into the TXUSERCLKIN port changes

Figure 2-10 shows the reset sequence for the transmit datapath.

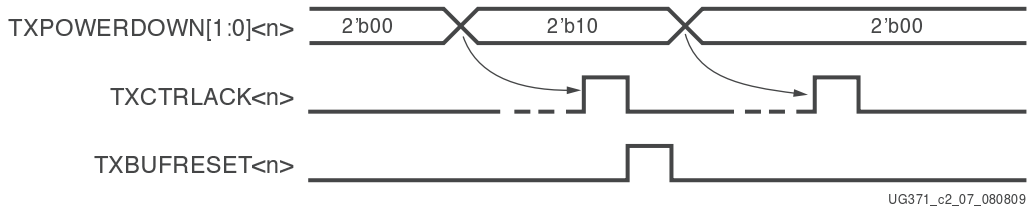

Figure 2-10: **GTH Reset for the Transmit Datapath**

Note relevant to Figure 2-10:

1. The TXCTRLACK<n> signal can be High for more than 1 DCLK clock cycle.

To reset the transmit datapath in the GTH transceiver:

1. Change TXPOWERDOWN<n>[1:0] to `2'b10` and wait for TXCTRLACK<n> to go High.
2. Assert TXBUFRESET<n> for one TXUSERCLKIN clock cycle.

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3. Change TXPOWERDOWN<n>[1:0] to `2'b00`. The transmitter is ready for normal operation.

Resetting the Receive Datapath

The reset datapath of the GTH transceiver must be reset under these conditions:

- After a line rate change
- When the clock going into the RXUSERCLKIN port changes
- When the receiver CDR loses lock as a result of:
  - The remote link powering up
  - Disconnecting and connecting RXN/RXP serial pins

Figure 2-11 shows the reset sequence for the receive datapath.

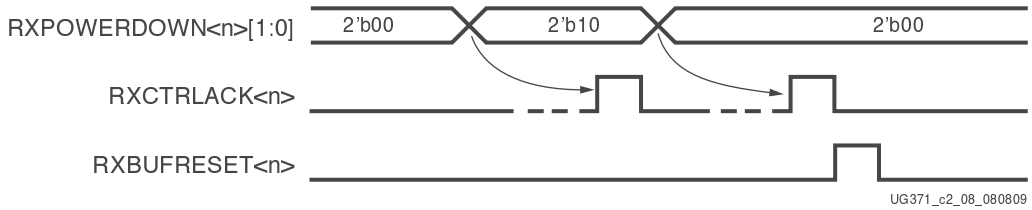

Figure 2-11: **GTH Reset for the Receive Datapath**

Note relevant to Figure 2-11:

1. The RXCTRLACK<n> signal can be High for more than 1 DCLK clock cycle.

To reset the receive datapath in the GTH transceiver:

1. Change RXPOWERDOWN<n>[1:0] to `2'b10` and wait for RXCTRLACK<n> to go High. The CDR is disabled.
2. Change RXPOWERDOWN<n>[1:0] to `2'b00` and wait for RXCTRLACK<n> to go High. The CDR is enabled.
3. Assert RXBUFRESET<n> for one RXUSERCLKIN clock cycle. The receiver is ready for normal operation.

Power Down

Functional Description

The GTH transceiver offers different levels of power control. Part of the power-down functionality includes resetting certain logic within the GTH transceiver.

Ports and Attributes

Table 2-12 defines the power-down ports.

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Table 2-12: **Power-Down Ports**

Port	Dir	Clock Domain	Description
POWERDOWN0 POWERDOWN1 POWERDOWN2 POWERDOWN3	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal powers off the corresponding lane. It is used to place individual lanes in a low power state. This port is used on a per-lane basis even when multiple lanes are configured as a single logical link.
RXPOWERDOWN0[1:0] RXPOWERDOWN1[1:0] RXPOWERDOWN2[1:0] RXPOWERDOWN3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal requests the receiver power state: `00`: Normal operation `10`: Power-off receiver logic. The PLL continues to operate in this state. This port must always be set to `2'b10` during initialization and when GTHRESET is asserted. If the Quad is configured as a x4 link, only the port from Lane 0 is valid.
TXPOWERDOWN0[1:0] TXPOWERDOWN1[1:0] TXPOWERDOWN2[1:0] TXPOWERDOWN3[1:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This control signal requests the transmitter power state: `00`: Normal operation `10`: Power-off transmitter logic. The PLL continues to operate in this state. This port must always be set to `2'b10` during initialization and when GTHRESET is asserted. If the Quad is configured as a x4 link, only the port from Lane 0 is valid.

Table 2-13 defines the power-down attributes.

Table 2-13: **Power-Down Attributes**

Attribute	Type	Description
GTH_CFG_PWRUP_LANE0 GTH_CFG_PWRUP_LANE1 GTH_CFG_PWRUP_LANE2 GTH_CFG_PWRUP_LANE3	1-bit Binary	This control attribute powers off the corresponding lane. This attribute is set to `1'b1` to power up the corresponding GTH lane.

Using Power Down

To activate the power-down mode on a per lane basis, use either the POWERDOWN<n> port or the GTH_CFG_PWRUP_LANE<n> attribute.

The TXPOWERDOWN and RXPOWERDOWN ports are used to activate the power down on the transmitter or the receiver, respectively.

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Loopback

Functional Description

The GTH transceiver supports these loopback modes:

- Far-end Loopback (line loopback)
- Near-end PCS Loopback
- Near-end PMA Loopback

Far-end Loopback

The Far-end loopback mode uses external equipment to generate and check test data. The loopback occurs after passing the deserializer of the PMA. The entire PCS section is bypassed except for the data multiplexers closest to the PMA. The loopback path works only when the external test equipment uses the same reference clock as the PMA.

Figure 2-12 shows the Far-end loopback datapath.

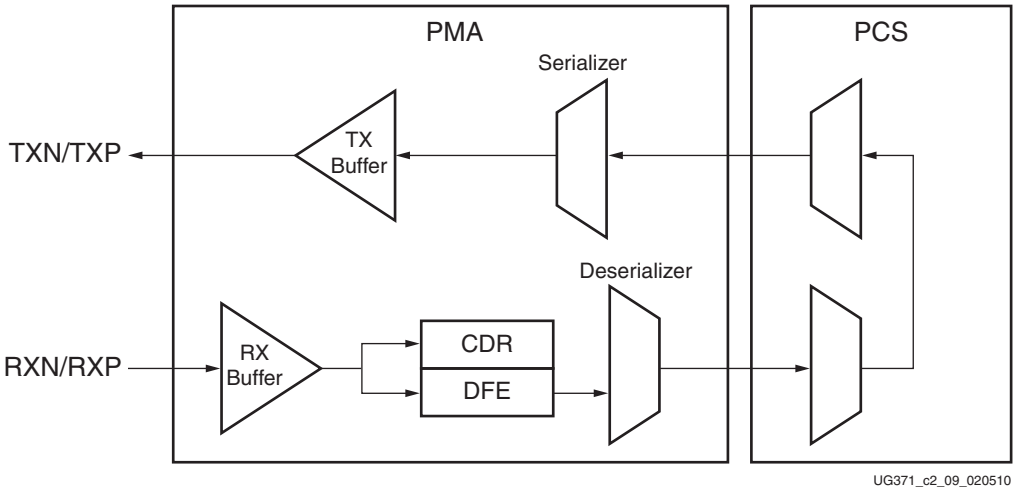

Figure 2-12: **Far-end Loopback**

Near-end PCS Loopback

In the Near-end PCS loopback mode, data is generated by user logic and looped back internal to the PCS. Then the data is checked by the user logic. Any PCS operating mode (8B/10B mode, raw mode, etc.) can be used. The PMA is not used.

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Figure 2-13 shows the PCS internal loopback path.

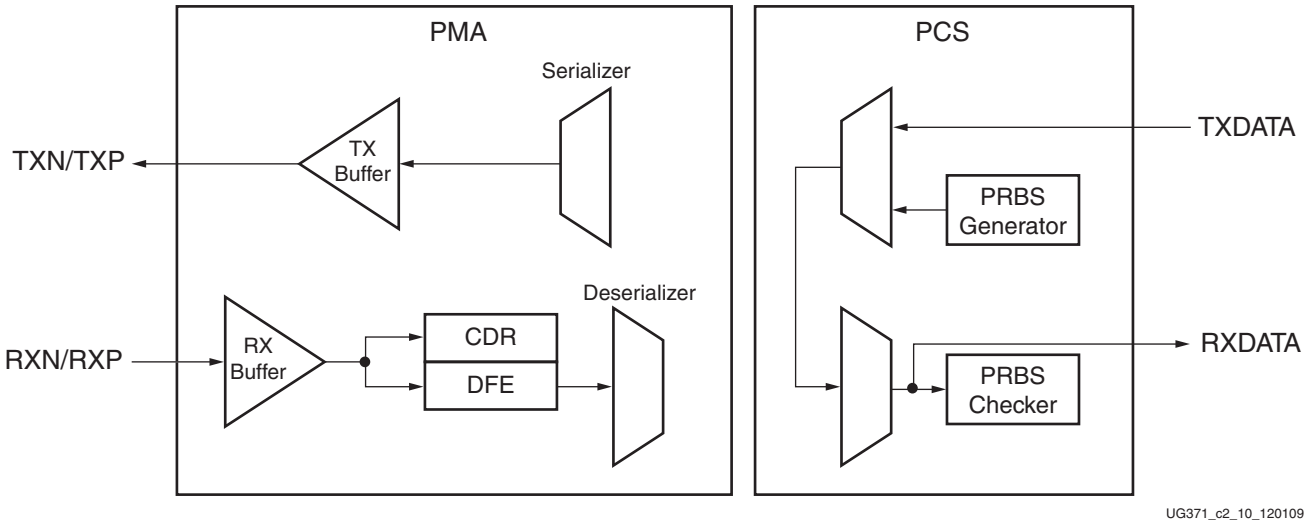

Figure 2-13: **Near-end PCS Loopback**

Near-end PMA Loopback

This mode uses either user logic or the PRBS generator/checker to generate and check the test data. The serial loopback path to the RX buffer is after the TX pre-driver and before the TX buffer. In this mode, the operation for all enabled PCS and PMA functional blocks in the transmitter and receiver channel can be verified.

Figure 2-14 shows a simplified block diagram of the Near-end PMA loopback mode.

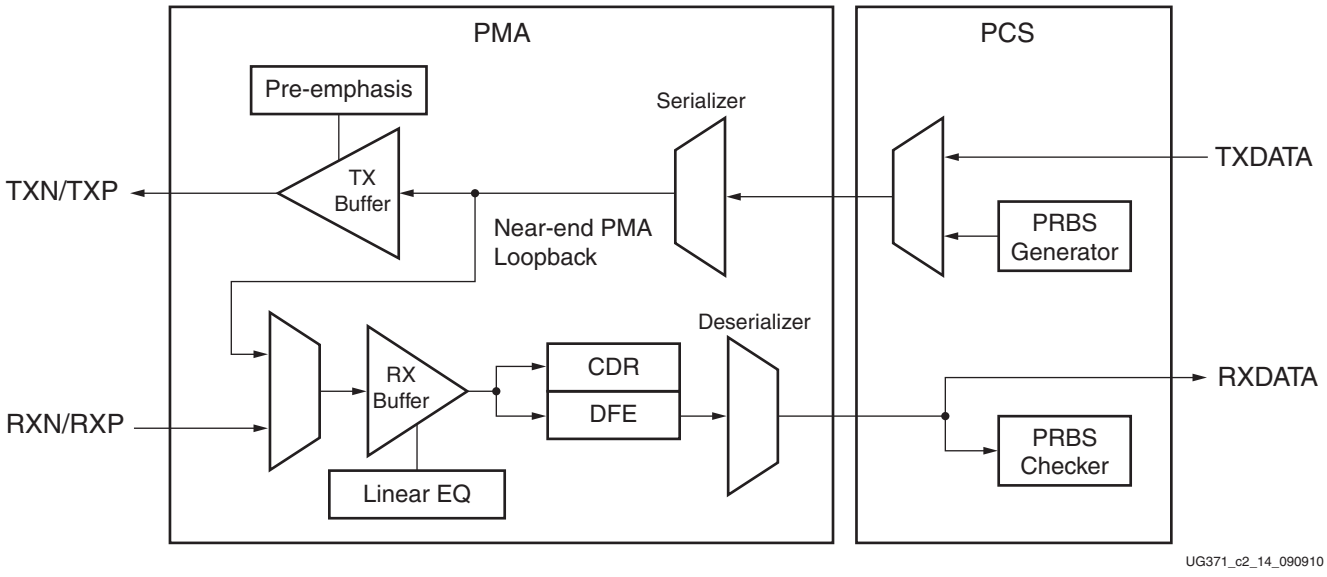

Figure 2-14: **Near-end PMA Loopback**

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Ports and Attributes

There are no loopback ports. Table 2-14 defines the loopback attributes.

Table 2-14: **Loopback Attributes**

Attribute	Type	Description
PMA_LPBK_CTRL_LANE0 PMA_LPBK_CTRL_LANE1 PMA_LPBK_CTRL_LANE2 PMA_LPBK_CTRL_LANE3	16-bit Hex	This attribute configures the PMA loopback mode. [15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: Configure the source of the on-chip loopback connection to the RX: `2'b00`: User loopback disabled `2'b01`: Reserved `2'b10`: TX pre-driver `2'b11`: Reserved
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [10:8]: PRBS checker mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [7:4]: PCS RX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved [3:0]: PCS TX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved

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Dynamic Reconfiguration Port

Functional Description

The dynamic reconfiguration port (DRP) allows the dynamic change of parameters of the GTHE1_QUAD primitive. The DRP interface is a processor-friendly synchronous interface with an address bus (DADDR) and separated data buses for reading (DO) and writing (DI) configuration data to the GTH Quad. An enable signal (DEN), a read/write signal (DWE), and a ready/valid signal (DRDY) are the control signals that implement read and write operations, indicate operation completion, or indicate the availability of data. Refer to UG360, *Virtex-6 FPGA Configuration User Guide* for detailed descriptions and timing diagrams of the DRP operations.

Ports and Attributes

Table 2-15 defines the DRP ports.

Table 2-15: **DRP Ports**

Port	Dir	Clock Domain	Description
DADDR[15:0]	In	DCLK	This input bus is the DRP address bus.
DCLK	In	N/A	This input is the DRP interface clock. It is also used as the management interface clock when the management interface is enabled. This clock must be connected and available all the time for the GTHE1_QUAD primitive to initialize properly, even if the DRP or the management interface is not used in the design.
DEN	In	DCLK	This input is the DRP enable signal. 0: No read or write operation performed. 1: Enables a read or write operation.
DI[15:0]	In	DCLK	This input bus is the data bus for writing configuration data from the FPGA logic resources to the GTHE1_QUAD primitive.
DISABLEDRP	In	DCLK	This input switches between the DRP and the management interface blocks. 0: DRP interface is selected. 1: Management interface is selected.
DRPDO[15:0]	Out	DCLK	This output bus is the data bus for reading configuration data from the GTHE1_QUAD primitive to the FPGA logic resources.
DRDY	Out	DCLK	When asserted, this output indicates operation is complete for write operations and data is valid for read operations.
DWE	In	DCLK	This input is the DRP write enable: 0: Read operation when DEN is 1. 1: Write operation when DEN is 1.

Using the DRP Interface

To enable the DRP interface, the DISABLEDRP port is driven Low. When the DRP interface is enabled, the management interface must be disabled. When a read or write operation is in progress on DRP interfaces, GTHRESET must not be asserted.

Note: When the setting on the DISABLEDRP port is changed to switch between the DRP interface and the management interface, the user must wait two DCLK cycles for the change to take effect before accessing the registers.

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Management Interface

Functional Description

The management interface allows the dynamic change of parameters of the GTHE1_QUAD primitive. It also allows monitoring the status of certain blocks within the GTH transceiver.

The management interface has separate signals for the MMD, GTH lane, and register address fields. This interface is driven by DCLK. When the management interface is selected, the DRP interface must be disabled by setting the DISABLEDRP port.

Ports and Attributes

Table 2-16 defines the management interface ports. There are no management interface attributes.

Table 2-16: **Management Interface Ports**

Port	Dir	Clock Domain	Description
DCLK	In	N/A	This input is the DRP interface clock. It is also used as the management interface clock when the management interface is enabled. This clock must be connected and available all the time for the GTHE1_QUAD primitive to initialize properly, even if the DRP or the management interface is not used in the design.
DISABLEDRP	In	DCLK	This input switches between the DRP and the management interface blocks. 0: DRP interface is selected. 1: Management interface is selected.
MGMTPCSLANESEL[3:0]	In	DCLK	These inputs select the GTH lane of the management interface: 0001: Select GTH lane 0. 0010: Select GTH lane 1. 0100: Select GTH lane 2. 1000: Select GTH lane 3. The user can select more than one GTH lane for accessing the registers.
MGMTPCSMMDADDR[4:0]	In	DCLK	This input bus is the MMD address bus.
MGMTPCSRDACK	Out	DCLK	This output is the management interface read data valid signal. It indicates when data is valid for read operations.
MGMTPCSRDDATA[15:0]	Out	DCLK	This output bus is the management interface register read data bus.
MGMTPCSREGADDR[15:0]	In	DCLK	This input bus is the management interface register address bus.
MGMTPCSREGRD	In	DCLK	This input is the management interface read request valid signal.
MGMTPCSREGWR	In	DCLK	This input is the management interface write request valid signal.
MGMTPCSWRDATA[15:0]	In	DCLK	This input bus is the management interface register write data bus.

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Using the Management Interface

To enable the management interface:

1. Drive the DISABLEDRP port Low during GTH transceiver initialization.
2. When the GTHINITDONE signal goes High from completion of GTH transceiver initialization, drive the DISABLEDRP port High.

One example for implementing the above sequence in logic is to tie the DISABLEDRP port to the inverter of GTHINITDONE.

Note: When the setting on the DISABLEDRP port is changed to switch between the DRP interface and the management interface, the user must wait two DCLK cycles for the change to take effect before accessing the registers.

Figure 2-15 is a timing diagram for reading the register through the management interface.

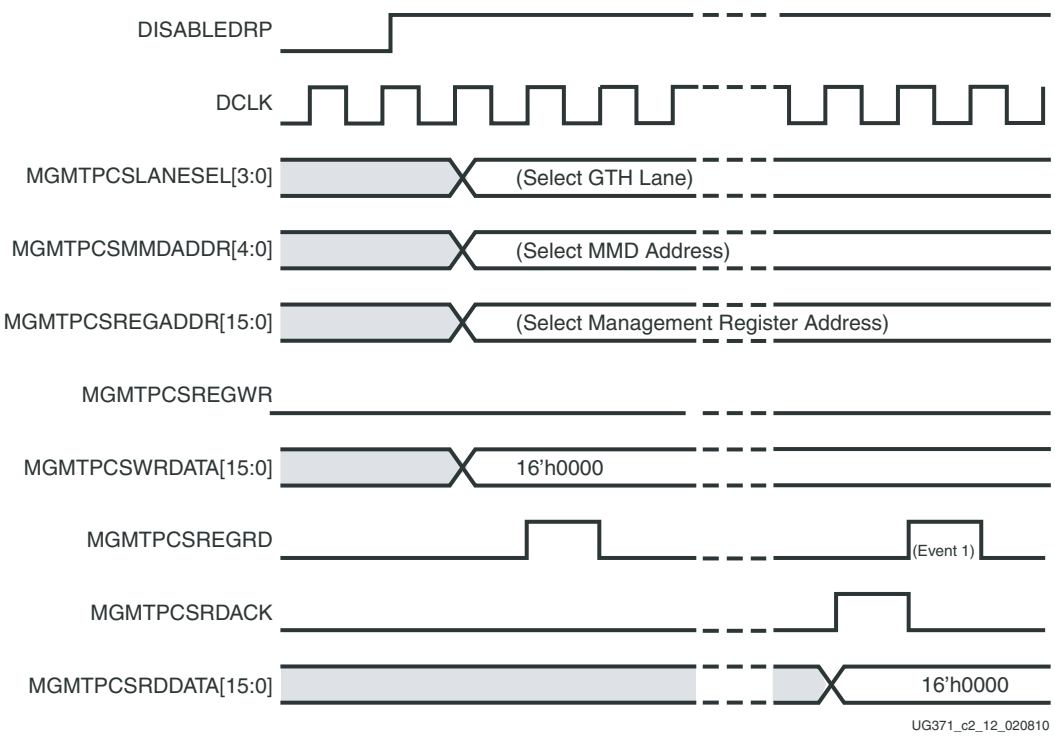

Figure 2-15: **Management Interface Read Access Timing Diagram**

The read access consists of MMD, GTH lane select, register address signals, and a single cycle pulse of the MGMTPCSREGRD signal. The read addresses must be held until the read access completes and returns an acknowledgment through the MGMTPCSRDACK signal. A read operation can be requested right after the acknowledgment indicator signal as shown in Event 1 of Figure 2-15. No read or write operation can be requested prior to the acknowledgment indicator signal. When a read operation is in progress on MGMT interfaces, GTHRESET must not be asserted.

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Figure 2-16 is a timing diagram for writing to the register through the management interface.

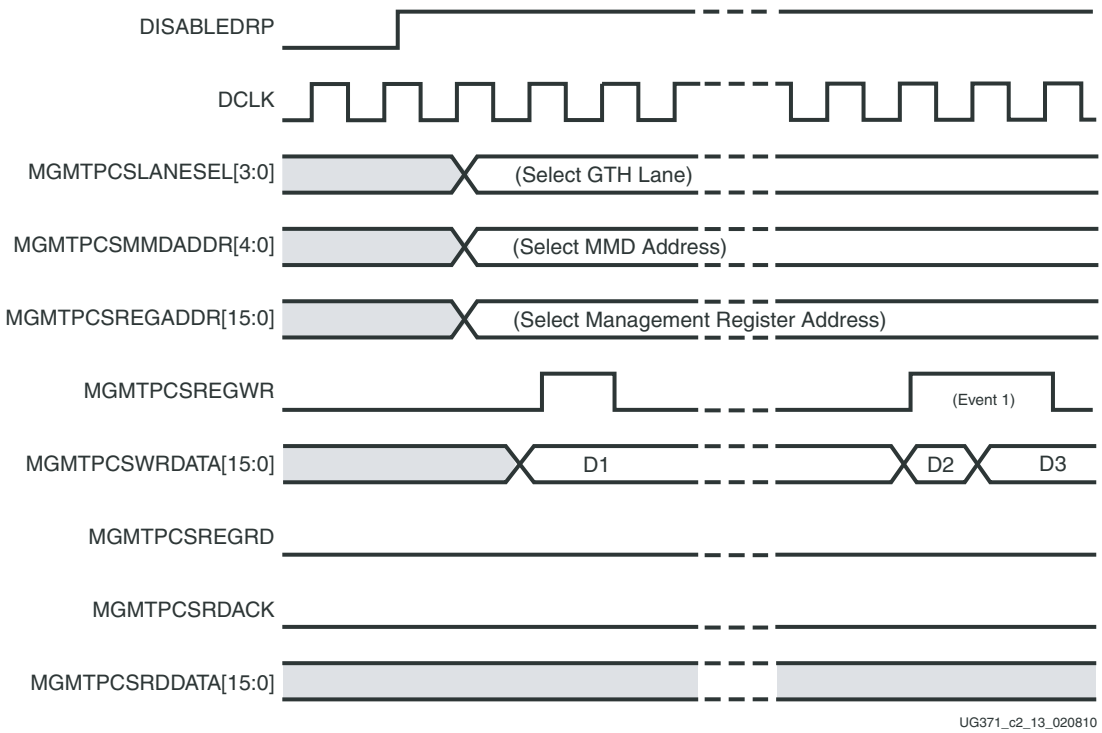

Figure 2-16: **Management Interface Write Access Timing Diagram**

The write access consists of the MMD, GTH lane select, and register address signals, the write data, and a single cycle pulse of the MGMTPCSREGWR signal. There is no acknowledgment indicator for a write operation. The management interface supports multiple write accesses by asserting the MGMTPCSREGWR signal as shown in Event 1 of Figure 2-16.

Multiple MGMTPCSLANESEL[3:0] signals can be asserted simultaneously for a write access.

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Differences Between the DRP and Management Interfaces

The DRP interface is a Xilinx standard configuration interface. The management interface is similar to an IEEE MDIO interface. Other considerations when using these interfaces are:

- The DRP interface requires an extra internal logic block to access the PCS/PMA control and status registers. The management interface does not.
- Both the DRP interface and management interface can access and change the settings of the PCS/PMA control registers.
- The DRP interface can access and update the configuration memory space (see Figure 2-17) to retain the setting change after GTHRESET by applying GTHINIT. The management interface can not access or update the configuration memory space. Therefore, any change in the setting of the PCS/PMA registers made by the management interface is not retained after GTHRESET.
- The DRP interface can access the FPGA interconnect data width settings (BUFFER_CONFIG_LANE<n>, TX_FABRIC_WIDTH<n> and RX_FABRIC_WIDTH<n>). The management interface can not be used to access these settings.

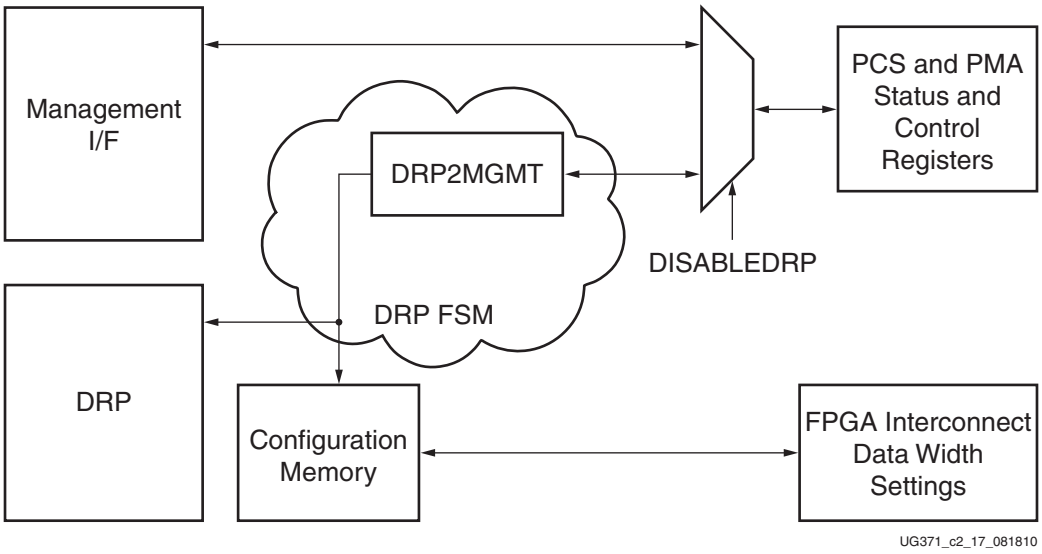

Figure 2-17: **DRP and Management Interface (MGMT)**

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Chapter 3

Transmitter

This chapter describes how to configure and use each of the functional blocks inside the GTH transmitter (TX). Each GTH transceiver in the GTH Quad includes an independent transmitter, which consists of a PCS and a PMA.

The key elements within the GTH TX are:

- FPGA TX Interface, page 77
- TX 8B/10B Block, page 84
- TX 10 Gigabit Ethernet 64B/66B Block, page 88
- TX Raw Mode, page 91
- TX Pattern Generator, page 95
- TX Polarity Control, page 98
- TX Configurable Driver, page 99

FPGA TX Interface

Functional Description

The FPGA TX interface is the FPGA's gateway to the TX datapath of the GTH transceiver. Applications transmit data through the GTH transceiver by writing data to the TXDATA port on the positive edge of TXUSERCLKIN. The width of the port can be configured depending on the mode chosen (see Table 3-1).

Table 3-1: **FPGA TX Interface Port Width**

Mode	Port Width
8B/10B mode	• 16 bits • 32 bits • 64 bits
64B/66B mode	• 64 bits
Raw mode	• 16 bits • 20 bits • 32 bits • 40 bits • 64 bits • 80 bits

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The rate of the parallel clock, TXUSERCLKIN, at the interface is determined by the TX line rate, the width of the TXDATA port, and whether or not 8B/10B mode is used. A block inside the PCS handles the mapping of the internal data width to the fabric data width selected in the design.

A data width converter block is included in the transmit datapath. This block includes:

- A clock generator that takes the internal PCS clock and generates TXUSERCLKOUT to the FPGA logic based on the external data width selected
- A four-byte-deep FIFO that handles the phase difference between the internal PCS clock and the external user clock
- A data width converter between the internal PCS data interface and the external data interface to the FPGA logic

The PCS_MODE_LANE<n>[3:0] attribute configures the internal data width, and the TX_FABRIC_WIDTH<n> attribute configures the external data width. Table 3-2 shows how the interface width for the TX datapath is selected.

Table 3-2: **FPGA TX Interface Datapath Configuration**

TX Data Mode	Internal PCS Data Width	Fabric Interface Data Width	PCS_MODE_LANE<n>[3:0]	TX_FABRIC_WIDTH<n>
8B/10B	20 bits	16 bits	0111	16
	20 bits	32 bits	0111	32
	20 bits	64 bits	0111	64
64B/66B	64 bits	64 bits	0001	6466
Raw	16 bits	16 bits	1010	16
	16 bits	32 bits	1010	32
	16 bits	64 bits	1010	64
	20 bits	20 bits	1011	20
	20 bits	40 bits	1011	40
	20 bits	80 bits	1011	80

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Figure 3-1 is a block diagram of the PCS logic. It shows the transmit datapath with the different modes and the data converter block.

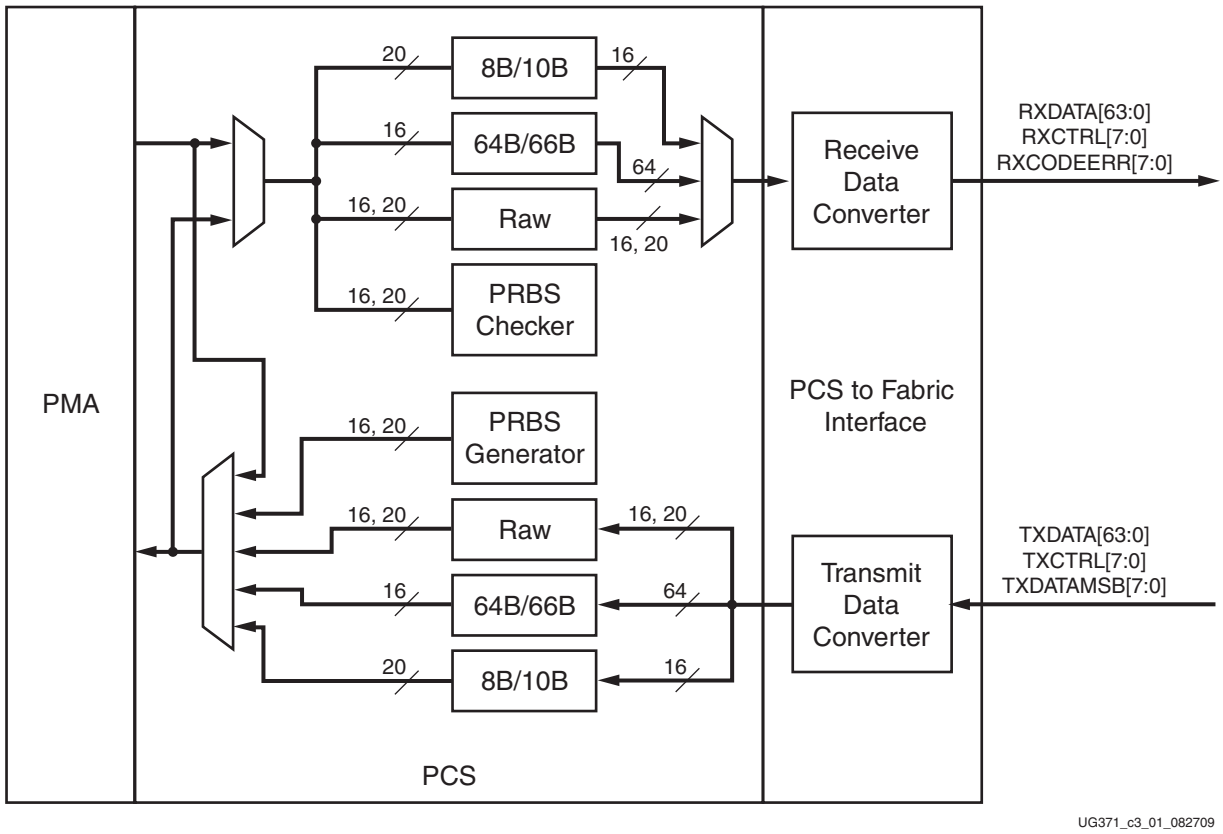

Figure 3-1: **PCS Block Diagram**

The user must consider these restrictions when configuring the fabric data width:

- The fabric interface data width must be the same for both the transmitter and receiver within a GTH lane.
- The data mode must be the same for both the transmitter and receiver within a GTH lane.
- The data mode must be the same on all four GTH lanes within a Quad.

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Ports and Attributes

Table 3-3 defines the FPGA TX interface ports.

Table 3-3: **FPGA TX Interface Ports**

Port	Dir	Clock Domain	Description
GTHX4LANE	In	Async	When this port is asserted, GTH lanes 0, 1, 2, and 3 are configured into a single x4 link.
TXBUFRESET0 TXBUFRESET1 TXBUFRESET2 TXBUFRESET3	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This port resets the buffer inside the TX data converter. Both the internal TX clock and TXUSERCLKIN<n> must be stable before a reset can be applied to the buffer.
TXCTRL0[7:0] TXCTRL1[7:0] TXCTRL2[7:0] TXCTRL3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	These inputs either indicate control of TXDATA<n> or they are used as an extension of TXDATA<n> depending on the mode selected in the transmitter datapath: 8B/10B: These inputs are asserted when TXDATA<n> is an 8B/10B K character. TXCTRL<n>[7] corresponds to TXDATA<n>[63:56] TXCTRL<n>[6] corresponds to TXDATA<n>[55:48] TXCTRL<n>[5] corresponds to TXDATA<n>[47:40] TXCTRL<n>[4] corresponds to TXDATA<n>[39:32] TXCTRL<n>[3] corresponds to TXDATA<n>[31:24] TXCTRL<n>[2] corresponds to TXDATA<n>[23:16] TXCTRL<n>[1] corresponds to TXDATA<n>[15:8] TXCTRL<n>[0] corresponds to TXDATA<n>[7:0] 64B/66B: These inputs are 64B/66B control bits. Raw mode: These inputs are used as part of TXDATA<n>[71:64].
TXDATA0[63:0] TXDATA1[63:0] TXDATA2[63:0] TXDATA3[63:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This input bus is the transmit data bus of the transmit interface from the FPGA.
TXDATAMSB0[7:0] TXDATAMSB1[7:0] TXDATAMSB2[7:0] TXDATAMSB3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This bus extends the transmit data bus as TXDATA<n>[79:72].
TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	In	N/A	This port provides a clock for the internal transmitter PCS datapath. It is a buffered version of the TXUSERCLKOUT<n>. This clock must be stable for the RXCTRLACK<n> and RXRATE<n> ports to be active.
TXUSERCLKOUT0 TXUSERCLKOUT1 TXUSERCLKOUT2 TXUSERCLKOUT3	Out	N/A	This port is the transmit parallel clock output based on the transmitter data bus width, TXRATE<n>, and SAMPLERATE<n>. This clock is used to drive TXUSERCLKIN<n> through a buffer.

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Table 3-4 defines the FPGA TX interface attributes.

Table 3-4: **FPGA TX Interface Attributes**

Attribute	Type	Description
BUFFER_CONFIG_LANE0 BUFFER_CONFIG_LANE1 BUFFER_CONFIG_LANE2 BUFFER_CONFIG_LANE3	16-bit Hex	This attribute defaults to `16'h4004`. [15:4]: TX_BUFFER_CONFIG[11:0] read pointer adjustment for TX buffer in the data converter. • For auto adjustment mode, TX_BUFFER_CONFIG[11:0] = `12'h400`. • For manual adjustment mode, TX_BUFFER_CONFIG[11:0] settings depend on TX_FABRIC_WIDTH and if the GTH transceivers within a Quad are configured as a x4 link (GTHX4LANE = `1'b1`): • x4 (GTHX4LANE = `1'b1`): [TX_FABRIC_WIDTH] = [TX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `12'h0A4` "32" (DRP value `3'b011`): `12'h394` "40" (DRP value `3'b101`): `12'h394` "64" (DRP value `3'b010`): `12'h250` "80" (DRP value `3'b110`): `12'h250` "6466" (DRP value `3'b111`): `12'h0A4` • x1 (GTHX4LANE = `1'b0`): [TX_FABRIC_WIDTH] = [TX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `12'h23C` "32" (DRP value `3'b011`): `12'h0E8` "40" (DRP value `3'b101`): `12'h0E8` "64" (DRP value `3'b010`): `12'h3A8` "80" (DRP value `3'b110`): `12'h3A8` "6466" (DRP value `3'b111`): `12'h23C` [4:0]: RX_BUFFER_CONFIG[3:0] read pointer adjustment for RX buffer in the data converter. • For auto adjustment mode, RX_BUFFER_CONFIG[3:0] = `0100`. • For manual adjustment mode, RX_BUFFER_CONFIG[3:0] settings depend on the RX_FABRIC_WIDTH: [RX_FABRIC_WIDTH] = [RX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `4'b0001` "32" (DRP value `3'b011`): `4'b0000` "40" (DRP value `3'b101`): `4'b0000` "64" (DRP value `3'b010`): `4'b0000` "80" (DRP value `3'b110`): `4'b0000` "6466" (DRP value `3'b111`): `4'b0001`

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Table 3-4: **FPGA TX Interface Attributes *(Cont'd)***

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [10:8]: PRBS checker mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [7:4]: PCS RX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved [3:0]: PCS TX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved

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Table 3-4: **FPGA TX Interface Attributes *(Cont'd)***

Attribute	Type	Description
TX_FABRIC_WIDTH0 TX_FABRIC_WIDTH1 TX_FABRIC_WIDTH2 TX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the transmitter. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

Transmit Clocking

The GTH transceiver provides a parallel clock to the FPGA TX interface, TXUSERCLKOUT. The user design must drive this clock to TXUSERCLKIN through either a BUFG or a BUFR. TXUSERCLKIN is the main synchronization clock for all signals into the TX side of the GTH transceiver.

Figure 3-2 is a block diagram of the FPGA TX interface clocking.

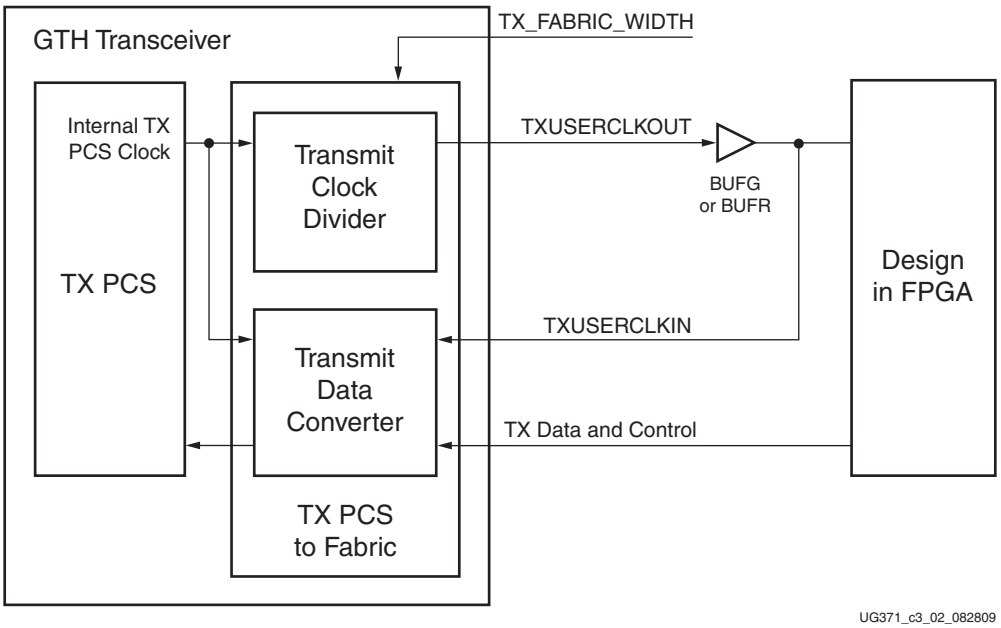

Figure 3-2: **FPGA TX Interface Clocking**

The user must consider these restrictions for the transmit clocking on the GTH transceiver:

- Within a GTH Quad, the four transmitters can share one BUFG/BUFR as long as the line rate, fabric data width, and encoding are the same across the four transmitters.
- Between GTH Quads, a transmitter of one Quad can share one BUFG/BUFR with a transmitter from another Quad as long as the line rate, fabric data width, and encoding are the same across those transmitters.
- The transmitter cannot use the same clock as the receiver; that is, TXUSERCLKIN and RXUSERCLKIN cannot be sourced from the same clock.

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Configuring the Transmitter for Multi-lane Applications

The GTHX4LANE port in GTH transceivers is used for multi-lane applications that require minimum skew across channels. To configure four GTH lanes within a Quad into a single x4 link, GTHX4LANE must be tied High. When configured in a single x4 link, a change in the control settings on the master lane also causes the same effect on the slaves. An exception to this is the POWERDOWN port. In this x4 link configuration, the buffers across the four transmit data converter are synchronized for minimizing skew.

TX 8B/10B Block

Functional Description

Many protocols use 8B/10B encoding on outgoing data. 8B/10B is an industry-standard encoding scheme that trades two bits of overhead per byte for improved performance. The GTH transceiver includes an 8B/10B encoder to encode TX data without consuming FPGA resources.

Ports and Attributes

Table 3-5 defines the TX 8B/10B block ports.

Table 3-5: **TX 8B/10B Block Ports**

Port	Dir	Clock Domain	Description
TXCTRL0[7:0] TXCTRL1[7:0] TXCTRL2[7:0] TXCTRL3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	These inputs indicate control of TXDATA<n> or they are used as an extension of TXDATA<n> depending on the mode selected in the transmitter datapath: 8B/10B: These inputs are asserted when TXDATA<n> is an 8B/10B K character. TXCTRL<n>[7] corresponds to TXDATA<n>[63:56] TXCTRL<n>[6] corresponds to TXDATA<n>[55:48] TXCTRL<n>[5] corresponds to TXDATA<n>[47:40] TXCTRL<n>[4] corresponds to TXDATA<n>[39:32] TXCTRL<n>[3] corresponds to TXDATA<n>[31:24] TXCTRL<n>[2] corresponds to TXDATA<n>[23:16] TXCTRL<n>[1] corresponds to TXDATA<n>[15:8] TXCTRL<n>[0] corresponds to TXDATA<n>[7:0] 64B/66B: These inputs are 64B/66B control bits. Raw mode: These inputs are used as part of TXDATA<n>[71:64].
TXDATA0[63:0] TXDATA1[63:0] TXDATA2[63:0] TXDATA3[63:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This input bus is the transmit data bus of the transmit interface from the FPGA.

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Table 3-6 defines the TX 8B/10B block attributes.

Table 3-6: **TX 8B/10B Block Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX. [14]: Loopback PCS TX to PCS RX. [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 3-6: **TX 8B/10B Block Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. It varies by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX Raw FIFO [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset 8B/10B TX FIFO [1]: Reset RX loopback FIFO [0]: Reset 64B/66B and PRBS TX FIFO
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from theVirtex-6 FPGA GTH Transceiver Wizard. [1:0]: This attribute controls the datapath resets. It varies by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
TX_FABRIC_WIDTH0 TX_FABRIC_WIDTH1 TX_FABRIC_WIDTH2 TX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the transmitter. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

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Enabling 8B/10B Mode

Follow these steps to enable the 8B/10B mode in the GTH transmitter:

1. Set PCS_MODE_LANE<n>[3:0] to `4'b0111`.
2. Set PCS_RESET_LANE<n> to `0xFC5B`.

- Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
- Set TX_FABRIC_WIDTH<n> to either “16”, “32”, or “64” depending on the application.

The 8B/10B table includes special characters (K characters) that are often used for control functions. To transmit TXDATA as a K character instead of regular data, the TXCTRL port must be driven High.

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TX 10 Gigabit Ethernet 64B/66B Block

Functional Description

Some high-speed data rate protocols use 64B/66B encoding to reduce the overhead of 8B/10B encoding while retaining the benefits of an encoding scheme. The GTH transceiver implements the 64B/66B block based on the IEEE 802.3-2008 Clause 49, "Physical Sublayer (PCS) for 64B/66B, type 10GBASE-R." The transmit 64B/66B block includes the scrambler and the gearbox.

Ports and Attributes

Table 3-7 defines the TX 10 Gb Ethernet 64B/66B block ports.

Table 3-7: **TX 10 10 Gb Ethernet 64B/66B Block Ports**

Port	Dir	Clock Domain	Description
TXCTRL0[7:0] TXCTRL1[7:0] TXCTRL2[7:0] TXCTRL3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	These inputs indicate control of TXDATA<n> or they are used as an extension of TXDATA<n> depending on the mode selected in the transmitter datapath: 8B/10B: These inputs are asserted when TXDATA<n> is an 8B/10B K character. TXCTRL<n>[7] corresponds to TXDATA<n>[63:56] TXCTRL<n>[6] corresponds to TXDATA<n>[55:48] TXCTRL<n>[5] corresponds to TXDATA<n>[47:40] TXCTRL<n>[4] corresponds to TXDATA<n>[39:32] TXCTRL<n>[3] corresponds to TXDATA<n>[31:24] TXCTRL<n>[2] corresponds to TXDATA<n>[23:16] TXCTRL<n>[1] corresponds to TXDATA<n>[15:8] TXCTRL<n>[0] corresponds to TXDATA<n>[7:0] 64B/66B: These inputs are 64B/66B control bits. Raw mode: These inputs are used as part of TXDATA<n>[71:64].
TXDATA0[63:0] TXDATA1[63:0] TXDATA2[63:0] TXDATA3[63:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This input bus is the transmit data bus of the transmit interface from the FPGA.

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Table 3-8 defines the TX 10 Gb Ethernet 64B/66B block attributes.

Table 3-8: **TX 10 10 Gb Ethernet 64B/66B Block Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX. [14]: Loopback PCS TX to PCS RX. [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 3-8: **TX 10 10 Gb Ethernet 64B/66B Block Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. It varies by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: This attribute controls the datapath resets. It varies by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
TX_FABRIC_WIDTH0 TX_FABRIC_WIDTH1 TX_FABRIC_WIDTH2 TX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the transmitter. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode The default for these attributes is "6466."

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Enabling 64B/66B Mode

Follow these steps to enable the 64B/66B mode in the GTH transmitter:

1. Set PCS_MODE_LANE<n>[3:0] to `4'b0001`.
2. Set PCS_RESET_LANE<n> to `0xF3FE`.
3. Set PCS_RESET_1_LANE<n>[1:0] to `2'b10`.
4. Set TX_FABRIC_WIDTH<n> to "6466."

TX Raw Mode

Functional Description

The GTH transceiver provides another datapath mode for non-encoded applications or when the user wants to bypass the 8B/10B and 64B/66B blocks.

Ports and Attributes

Table 3-9 defines the TX raw mode ports.

Table 3-9: **TX Raw Mode Ports**

Port	Dir	Clock Domain	Description
TXCTRL0[7:0] TXCTRL1[7:0] TXCTRL2[7:0] TXCTRL3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	These inputs indicate control of TXDATA<n> or they are used as an extension of TXDATA<n> depending on the mode selected in the transmitter datapath: 8B/10B: These inputs are asserted when TXDATA<n> is an 8B/10B K character. TXCTRL<n>[7] corresponds to TXDATA<n>[63:56] TXCTRL<n>[6] corresponds to TXDATA<n>[55:48] TXCTRL<n>[5] corresponds to TXDATA<n>[47:40] TXCTRL<n>[4] corresponds to TXDATA<n>[39:32] TXCTRL<n>[3] corresponds to TXDATA<n>[31:24] TXCTRL<n>[2] corresponds to TXDATA<n>[23:16] TXCTRL<n>[1] corresponds to TXDATA<n>[15:8] TXCTRL<n>[0] corresponds to TXDATA<n>[7:0] 64B/66B: These inputs are 64B/66B control bits. Raw mode: These inputs are used as part of TXDATA<n>[71:64].
TXDATA0[63:0] TXDATA1[63:0] TXDATA2[63:0] TXDATA3[63:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This input bus is the transmit data bus of the transmit interface from the FPGA.
TXDATAMSB0[7:0] TXDATAMSB1[7:0] TXDATAMSB2[7:0] TXDATAMSB3[7:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	This bus extends the transmit data bus as TXDATA<n>[79:72].

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Table 3-10 defines the TX raw mode attributes.

Table 3-10: **TX Raw Mode Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [10:8]: PRBS checker mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [7:4]: PCS RX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved [3:0]: PCS TX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved

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Table 3-10: **TX Raw Mode Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. It varies by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: This attribute controls the datapath resets. It varies by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
TX_FABRIC_WIDTH0 TX_FABRIC_WIDTH1 TX_FABRIC_WIDTH2 TX_FABRIC_WIDTH3	Integer	Defaults to "6466." This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the transmitter. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

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Enabling Raw Mode

Follow these steps to enable the Raw mode in the GTH transmitter:

1. If the transmit fabric data width is configured to 16 bits, 32 bits, or 64 bits
   a. Set PCS_MODE_LANE<n>[3:0] to `4'b1010`.
   b. Set PCS_RESET_LANE<n> to `0xFF3B`.
   c. Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
   d. Set TX_FABRIC_WIDTH<n> to “16”, “32”, or “64.”
2. If the transmit fabric data width is configured to 20 bits, 40 bits, or 80 bits
   a. Set PCS_MODE_LANE<n>[3:0] to `4'b1011`.
   b. Set PCS_RESET_LANE<n> to `0xFF3B`.
   c. Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
   d. Set TX_FABRIC_WIDTH<n> to “20”, “40”, or “80.”

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TX Pattern Generator

Functional Description

The GTH transceiver pattern generator block can generate the industry-standard PRBS patterns listed in Table 3-11.

Table 3-11: **PRBS Pattern**

Name	Polynomial	Length of Sequence	Description
PRBS7	$1 + X^6 + X^7$	$2^7 - 1$ bits	Characteristics are similar to 8B/10B data.
PRBS9	$1 + X^5 + X^9$	$2^9 - 1$ bits	Used by 10GBASE-LRM.
PRBS11	$1 + X^9 + X^{11}$	$2^{11} - 1$ bits	Used by 10BASE-KR link training.
PRBS23	$1 + X^{18} + X^{23}$	$2^{23} - 1$ bits	PRBS23 is often used for non-8B/10B encoding schemes. This is one of the recommended test patterns in the SONET specification.
PRBS31	$1 + X^{28} + X^{31}$	$2^{31} - 1$ bits	Characteristics are similar to 64B/66B data.

Ports and Attributes

There are no ports in the TX pattern generator.

Table 3-12 defines the TX pattern generator attributes.

Table 3-12: **TX Pattern Generator Attributes**

Attribute	Type	Description
PRBS_CFG_LANE0 PRBS_CFG_LANE1 PRBS_CFG_LANE2 PRBS_CFG_LANE3	16-bit Hex	[15:4]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [3:2]: PRBS generate width `2'b11`: 20b `2'b10`: 16b Others: Reserved [1:0]: PRBS checker width `2'b11`: 20b `2'b10`: 16b Others: Reserved

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Table 3-12: **TX Pattern Generator Attributes *(Cont'd)***

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	Sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX. [14]: Loopback PCS TX to PCS RX. [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 3-12: **TX Pattern Generator Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. It varies by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: This attribute controls the datapath resets. It varies by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`

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TX Polarity Control

Functional Description

The GTH transceiver includes a TX polarity control function to invert outgoing data from the PCS before serialization and transmission.

Ports and Attributes

There are no TX polarity control ports.

Table 3-13 defines the TX polarity control attributes.

Table 3-13: **TX Polarity Control Attributes**

Attribute	Type	Description

PCS_MISC_CFG_0_LANE0
PCS_MISC_CFG_0_LANE1
PCS_MISC_CFG_0_LANE2
PCS_MISC_CFG_0_LANE3
	16-bit Hex	This attribute sets the polarity and PRBS configuration.
		[15:12]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
		[11]: Invert TX polarity
		[10]: RX polarity override enable
		[9]: RX polarity override value
		[8]: Reset the PRBS error counter when read
		[7]: Revert bit order of parallel data to serializer/deserializer TX
		[6]: Revert bit order of parallel data from serializer/deserializer RX
		[5:0]: Reserved.
		`6'h16` when TXRATE=`2'b00`
		`6'h17` when TXRATE=`2'b01`
		`6'h14` when TXRATE=`2'b10`
		`6'h14` when TXRATE=`2'b11`

Using TX Polarity Control

If the TXP/TXN differential traces are swapped on a board, use either the DRP or the management interface to set PCS_MISC_CFG_0_LANE<n>[11] register to `1'b1`. The register is located in:

- DRP Address
  - PCS_MISC_CFG_0_LANE0: `0x5001`
  - PCS_MISC_CFG_0_LANE1: `0x5101`
  - PCS_MISC_CFG_0_LANE2: `0x5201`
  - PCS_MISC_CFG_0_LANE3: `0x5301`
- Management Interface Address: `0x8001` with MMD Address `0x03`
  - Use the Lane Address setting to specify which GTH lane to access

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TX Configurable Driver

Functional Description

The GTH TX driver is a high-speed, current-mode differential output buffer. To maximize signal integrity, the TX driver includes these features:

- Differential voltage swing control
- Pre-cursor and post-cursor transmit emphasis
- Calibrated termination resistors

Figure 3-3 is a detailed diagram of the TX driver.

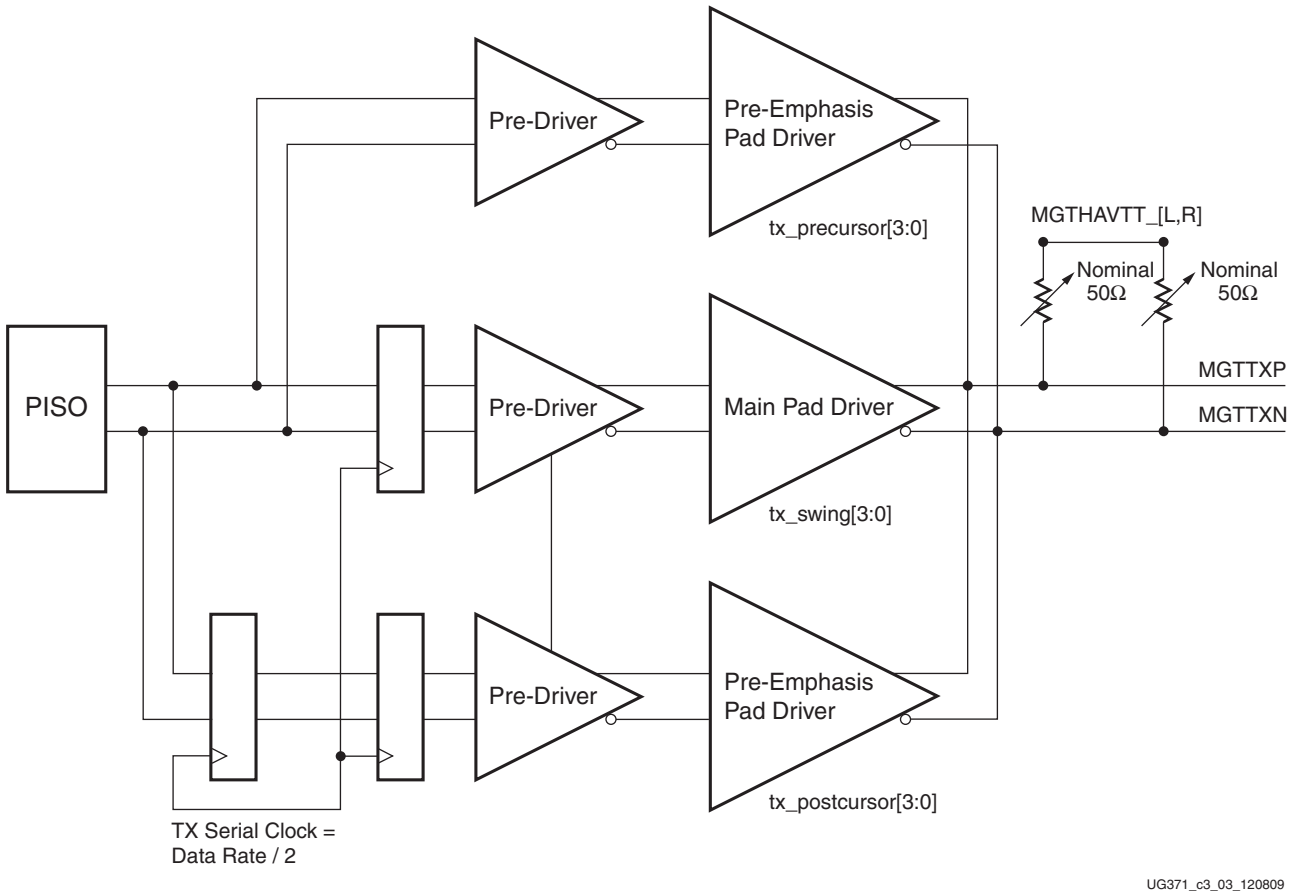

Figure 3-3: **TX Driver Structure**

The transmitter's output level can vary depending on the state of the system. Here are some common scenarios:

- Power-up, before configuration

  Differential zero: TXP is held Low; TXN is held High.
- During configuration

  Differential zero: TXP is held Low; TXN is held High.
- Reset

  Differential zero: TXP is held Low; TXN is held High.

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- Power down
  Floating: TXP and TXN should float High to VTTX (assuming AC-coupled mode)
- Near-end PCS loopback and Near-end PMA loopback
  TXP and TXN are transmitting live data

Ports and Attributes

Table 3-14 defines the TX configurable driver ports.

Table 3-14: **TX Configurable Driver Ports**

Port	Dir	Clock Domain	Description
TXDEEMPH0 TXDEEMPH1 TXDEEMPH2 TXDEEMPH3	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	Reserved. Tie this input to `0`.
TXMARGIN0[2:0] TXMARGIN1[2:0] TXMARGIN2[2:0] TXMARGIN3[2:0]	In	TXUSERCLKIN0 TXUSERCLKIN1 TXUSERCLKIN2 TXUSERCLKIN3	Reserved. Tie these inputs to `000`.
TXN0 TXN1 TXN2 TXN3 TXP0 TXP1 TXP2 TXP3	Out (Pad)	TX Serial Clock	TXP and TXN are the differential output pairs for each of the transmitters in the GTHE1_QUAD primitive. These ports represent pads. The location of these ports must be constrained and brought to the top level of the design.

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Table 3-15 defines the TX configurable driver attributes.

Table 3-15: **TX Configurable Driver Attributes**

Attribute	Type	Description
TX_CFG0_LANE0 TX_CFG0_LANE1 TX_CFG0_LANE2 TX_CFG0_LANE3	16-bit Binary	This attribute controls the differential voltage swing. [15:14]: Reserved: `2'h0` [13]: Active-High TX lane power down (tx_chpd) [12:7]: Reserved: `6'h00` [6:3]: TX output swing control and main tap/cursor control (tx_swing) Default: `4'h7` [2:0]: TX current bias fine swing control (tx_ibias) tx_bias = `3'h5`(1)

tx_swing (Binary)	TX_CFG0_LANE (Hex)	Voltage Swing (mV_{PPD})
0000	0x0005	450
0001	0x000D	500
0010	0x0015	550
0011	0x001D	600
0100	0x0025	650
0101	0x002D	700
0110	0x0035	750
0111	0x003D	800
1000	0x0045	850
1001	0x004D	900
1010	0x0055	950
1011	0x005D	1000
1100	0x0065	1050
1101	0x006D	1100
1110	0x0075	1150
1111	0x007D	1200

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Table 3-15: **TX Configurable Driver Attributes *(Cont'd)***

Attribute	Type	Description
TX_CFG1_LANE0 TX_CFG1_LANE1 TX_CFG1_LANE2 TX_CFG1_LANE3	16-bit Binary	This attribute enables the differential voltage swing and the pre-cursor and post-cursor transmit emphasis. [15:10]: Reserved. Tie these inputs to `6'b000011`. [9]: This bit gives control to tx_swing in the TX_CFG0_LANE<n> registers for voltage swing control (tx_swing_ovrrd_en). Set this bit to `1'b1`. [8]: This bit gives control to tx_postcursor and tx_precursor in the TX_PREEMPH_LANE<n> attribute for transmit post-cursor and pre-cursor emphasis (tx_premptap_ovrrd_en). Set this bit to `1'b1`. [7:0]: Reserved. Tie these inputs to `8'h00`.
TX_PREEMPH_LANE0 TX_PREEMPH_LANE1 TX_PREEMPH_LANE2 TX_PREEMPH_LANE3	16-bit Binary	This attribute controls the pre-cursor and post-cursor transmit emphasis. For pre-emphasis and post-emphasis settings, see Setting the TX Driver. [15:8]: Reserved. Tie these inputs to `8'h00`. [7:4]: Pre-emphasis settings for the first post-cursor (tx_postcursor). [3:0]: Pre-emphasis settings for the pre-cursor or the second post-cursor (tx_precursor).

Notes:

1. The hexadecimal values for TX_CFG0_LANE<n> assume that the defaults for the other bits in the register are used and that the channel is powered up and not in reset.

Setting the TX Driver

The TX amplitude and swing controls are set via attributes using the DRP or the Management interface.

Amplitude (Swing)

The override bit has to be set as specified:

- TX_CFG1_LANE<n>[9] = tx_swing_ovrrd_en = `1'b1`
- TX_CFG0_LANE<n>[6:3] = tx_swing (see Table 3-15 for voltage swing control settings)
- TX_CFG0_LANE<n>[2:0] = tx_ibias (see Table 3-15 for voltage swing control settings)

Post-Cursor Emphasis

The override bit has to be set as specified:

- TX_CFG1_LANE<n>[8] = tx_premptap_ovrrd_en = `1'b1`
- TX_PREEMPH_LANE<n>[7:4] = tx_postcursor

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Equation 3-1 can determine the tx_postcursor[3:0] value that provides the required emphasis. The value from Equation 3-1 has to be within the range 4'd0 to 4'd15.

$$tx_postcursor[3:0] = ROUND\left(\left(18 + 2(tx_swing[3:0])\right)\left(\left(1 - 10^{\frac{-|Emphasis(dB)|}{20}}\right) - 1\right)\right) \quad \text{Equation 3-1}$$

Alternatively, Table 3-16 can be used as a guide to setting tx_postcursor[3:0].

Table 3-16: **TX Post-Cursor Settings for Various TX Amplitudes**

tx_swing (mV_{PPD})	tx_swing	TX_PREEMPH_LANE<n>[7:4] = tx_post_cursor								
	TX_CFG0_LANE[6:3]	0 dB	1 dB	2 dB	3.5 dB	4.5 dB	6 dB	7 dB	8dB	9dB
450	4'b0000	4'd0	4'd1	4'd2	4'd4	4'd6	4'd7	4'd8	4'd9	4'd10
600	4'b0011	4'd0	4'd2	4'd4	4'd7	4'd9	4'd11	4'd12	4'd14	4'd15
700	4'b0101	4'd0	4'd2	4'd5	4'd8	4'd10	4'd13	4'd15	–	–
800	4'b0111	4'd0	4'd3	4'd6	4'd10	4'd12	4'd15	–	–	–
900	4'b1001	4'd0	4'd3	4'd7	4'd11	4'd14	–	–	–	–
1000	4'b1011	4'd0	4'd3	4'd7	4'd12	4'd15	–	–	–	–
1100	4'b1101	4'd0	4'd4	4'd8	4'd14	–	–	–	–	–
1200	4'b1111	4'd0	4'd4	4'd9	4'd15	–	–	–	–	–

Pre-Cursor Emphasis

The override bit has to be set as specified:

- TX_CFG1_LANE<n>[8] = tx_premptap_ovrrd_en = 1'b1
- TX_PREEMPH_LANE<n>[3:0] = tx_precursor (see Table 3-15 for pre-cursor control settings)

Equation 3-2 can determine the tx_precursor[3:0] value that provides the required emphasis. The value from Equation 3-2 has to be within the range 4'd0 to 4'd15.

$$ROUND\left(\frac{tx_precursor[3:0] - 1}{2} + 1\right) = ROUND\left(\left(18 + 2(tx_swing[3:0])\right)\left(\left(1 - 10^{\frac{-|Emphasis(dB)|}{20}}\right) - 1\right)\right) \quad \text{Equation 3-2}$$

Alternatively, Table 3-17 can be used as a guide to setting tx_precursor[3:0].

Table 3-17: **TX Pre-Cursor Settings for Various TX Amplitudes**

tx_swing (mV_{PPD})	tx_swing	TX_PREEMPH_LANE<n>[3:0] = tx_pre_cursor						
	TX_CFG0_LANE[6:3]	0 dB	0.75 dB	1.5 dB	2.5 dB	3.5 dB	4.5 dB	6 dB
450	4'b0000	4'd0	–	4'd5	4'd7	4'd10	4'd13	4'd15
600	4'b0011	4'd0	4'd3	4'd7	4'd11	4'd13	–	–
700	4'b0101	4'd0	4'd3	4'd7	4'd13	–	–	–
800	4'b0111	4'd0	4'd5	4'd9	4'd15	–	–	–
900	4'b1001	4'd0	4'd5	4'd11	–	–	–	–
1000	4'b1011	4'd0	4'd5	4'd11	–	–	–	–
1100	4'b1101	4'd0	4'd7	4'd13	–	–	–	–
1200	4'b1111	4'd0	4'd7	4'd15	–	–	–	–

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Chapter 4

Receiver

This chapter describes how to configure and use each of the functional blocks inside the GTH receiver (RX). Each GTH transceiver in the GTH Quad includes an independent receiver, which consists of a PCS and a PMA.

The key elements within the GTH RX are:

- RX Analog Front End, page 106
- RX Equalization, page 107
- RX CDR, page 111
- RX Polarity Control, page 113
- RX Pattern Checker, page 114
- RX Raw Mode, page 119
- RX 10 Gigabit Ethernet 64B/66B Block, page 124
- RX 8B/10B Block, page 128
- FPGA RX Interface, page 132

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RX Analog Front End

The RX analog front end (AFE) is a high-speed, current-mode, input differential buffer with calibrated termination resistors. Figure 4-1 shows the structure of the RX AFE.

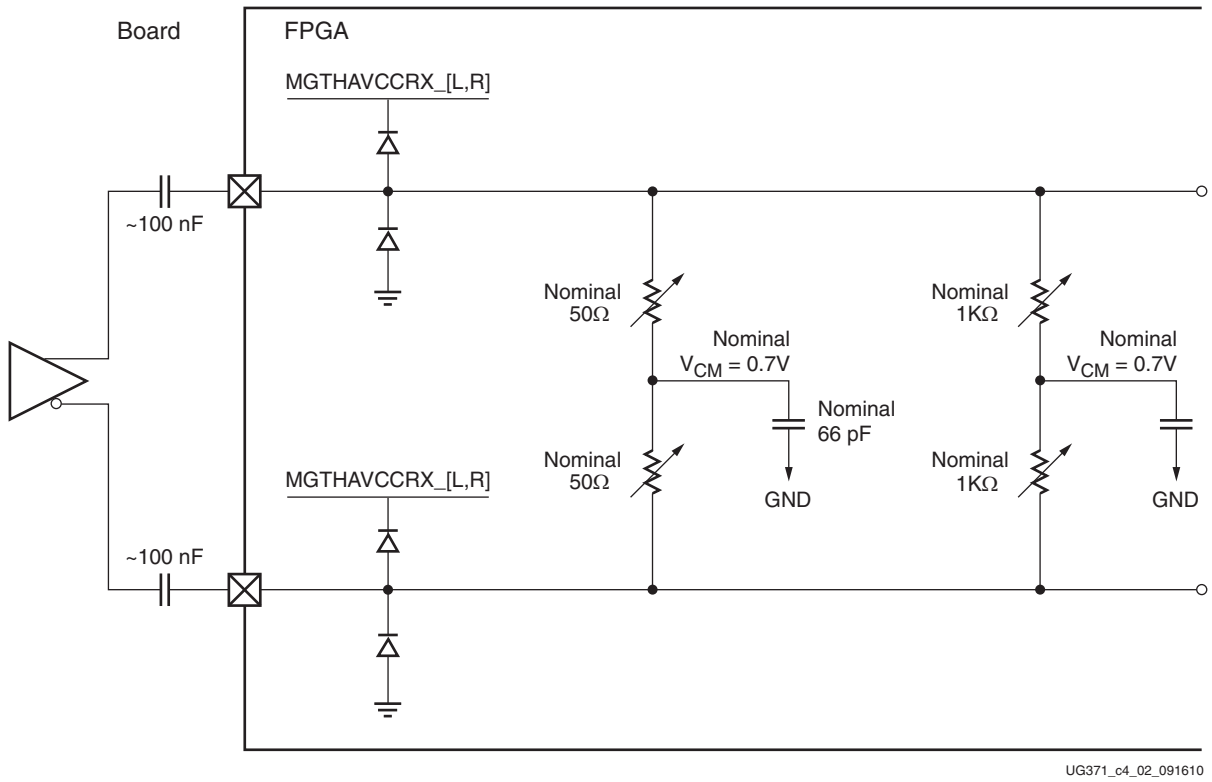

Figure 4-1: **Structure of the RX AFE**

Different conditions must be considered when configuring the RX AFE. Table 4-1 shows examples of those conditions.

Table 4-1: **RX AFE Board Interface Configurations**

RX Configuration						Recom-mended	Comments
Transceiver Power Pins Connected to Power	Transceiver GND Referenced with Link Partner	RX Driven by Link Partner	Coupling (AC/DC)	Transceiver Configured via Bitstream	RX Powered Down Via Attributes		
–	N	–	–	–	–	N	Link partners should be GND referenced, otherwise the relative offsets can damage the FPGA.
–	–	–	DC	–	–	N	Only AC coupling mode is supported
N	Y	Y	AC	–	–	Y	
Y	Y	Y	AC	N	N	Y	The receiver common mode becomes MGTHAVCCRX. The single-ended swing absolute value is limited by the maximum voltage value of the RXP/RXN signals specified in DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*.
Y	Y	Y	AC	N (configuration ongoing and not complete)	N	Y	
Y	Y	Y	AC	Y	Y	Y	

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Ports and Attributes

Table 4-2 defines the RX AFE ports.

Table 4-2: **RX AFE Ports**

Port	Dir	Clock Domain	Description
RXN0 RXN1 RXN2 RXN3 RXP0 RXP1 RXP2 RXP3	In (Pad)	RX Serial Clock	RXN and RXP are differential complements of each other, forming a differential receiver input pair. These ports represent pads. The location of these ports must be constrained and brought to the top level of the design.

Table 4-3 defines the RX analog front end attributes.

Table 4-3: **RX AFE Attributes**

Attribute	Type	Description
RX_CFG2_LANE0 RX_CFG2_LANE1 RX_CFG2_LANE2 RX_CFG2_LANE3	16-bit Binary	[15:13]: Reserved. Tie these inputs to `4'b0000`. [12]: RX AFE AC coupling mode enable. Set this input to `1'b1`. [11:0]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.

Interfacing to the RX AFE

The RX AFE is only to be used with external AC coupling capacitors. The recommended value for the AC coupling capacitor is 100 nF. For the maximum and minimum swing requirements, refer to DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*.

RX Equalization

Functional Description

The GTH receiver has a continuous time linear equalizer (CTLE) and a decision feedback equalizer (DFE). The CTLE can be tuned to compensate for signal distortion due to high-frequency attenuation in the physical channel. It has 16 different frequency responses to allow for a close match to the channel. The user needs to manually tune the settings based on simulation or hardware testing results.

The DFE works in conjunction with the CTLE to further enhance the equalized eye by reducing the post-cursor tail of the transmitted bit. The DFE in this transceiver is implemented as a three-tap architecture. In addition to the DFE, an automatic gain control (AGC) block pre-scales the input to be optimal for the DFE. The built-in auto-adaptation algorithm automatically configures the DFE and the AGC for maximum internal eye height.

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Figure 4-2 provides a top-level illustration of the AFE with the CTLE, DFE, and CDR.

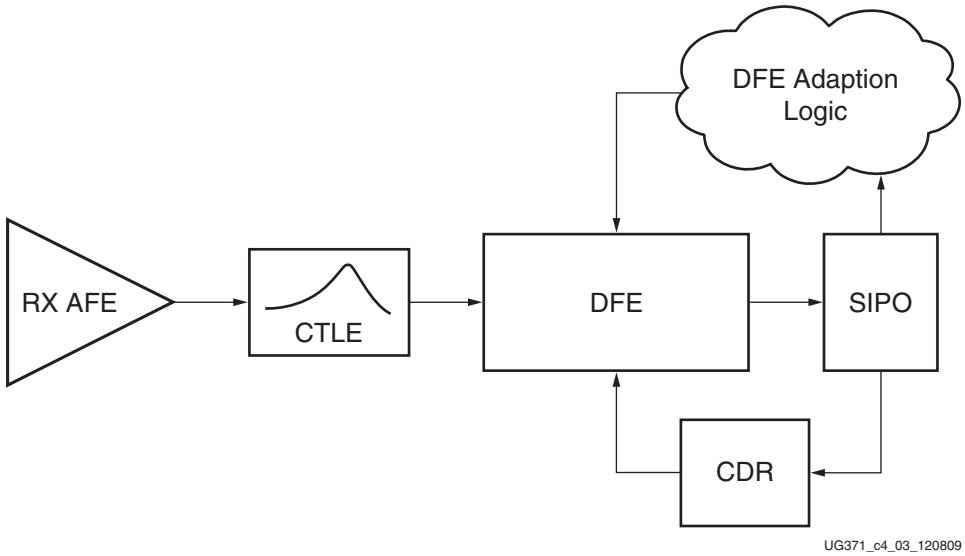

Figure 4-2: **RX Equalization Block Diagram**

Ports and Attributes

Table 4-4 defines the RX equalization ports.

Table 4-4: **RX Equalization Ports**

Port	Dir	Clock Domain	Description
DFETRAINCTRL0 DFETRAINCTRL1 DFETRAINCTRL2 DFETRAINCTRL3	In	DCLK	When the DFE is enabled, asserting this pin overrides completion of the DFE training.

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Table 4-5 defines the RX equalization attributes.

Table 4-5: **RX Equalization Attributes**

Attribute	Type	Description
DFE_TRAIN_CTRL_LANE0 DFE_TRAIN_CTRL_LANE1 DFE_TRAIN_CTRL_LANE2 DFE_TRAIN_CTRL_LANE3	16-bit Hex	This attribute controls the DFE. [15]: 8B/10B mode and PRBS train_ok qualifier for the DFE. This bit qualifies train_ok signal from the 8B/10B and the RX PRBS blocks. This bit defaults to `1'b1` for modes that use 8B/10B encoding or PRBS. [14]: Raw mode train_ok qualifier for the DFE. This bit qualifies the train_ok signal for Raw mode. This bit defaults to `1'b1` for modes that do not use 8B/10B or 64B/66B encoding or PRBS. [13]: 64B/66B mode train_ok qualifier for the DFE. This bit qualifies the train_ok signal from the 64B/66B RX block. This bit defaults to `1'b1` for modes that use 64B/66B encoding. [12:0]: DFE train limit. These bits contain the number (in 1K units) of consecutive error-free symbols that must be received before exiting DFE training mode. The setting on these bits varies per mode: • 64B/66B (use 10GBASE-KR as an example): `13'h04C4` • 8B/10B: `13'h03D0` • PRBS: `13'h04C4` • Raw: If data encoding is similar to 64B/66B, use `13'h04C4`. If data encoding is similar to 8B/10B, use `13'h03D0`.
RX_AEQ_VAL0_LANE0 RX_AEQ_VAL0_LANE1 RX_AEQ_VAL0_LANE2 RX_AEQ_VAL0_LANE3	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
RX_AEQ_VAL1_LANE0 RX_AEQ_VAL1_LANE1 RX_AEQ_VAL1_LANE2 RX_AEQ_VAL1_LANE3	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.

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Table 4-5: **RX Equalization Attributes *(Cont'd)***

<table>
<tr><th>Attribute</th><th>Type</th><th>Description</th></tr>
<tr><td>RX_CTLE_CTRL_LANE0
RX_CTLE_CTRL_LANE1
RX_CTLE_CTRL_LANE2
RX_CTLE_CTRL_LANE3</td><td>16-bit Hex</td><td>This attribute controls the RX CTLE peaking.
[15:8]: Reserved. Tie these inputs to 8'h00.
[7:4]: RX CTLE Peak Control. The peaking is mainly focused around 2.5 GHz.
<table>
<tr><th></th><th>dB - Nominal</th></tr>
<tr><td>0</td><td>0.15</td></tr>
<tr><td>1</td><td>0.36</td></tr>
<tr><td>2</td><td>0.74</td></tr>
<tr><td>3</td><td>0.96</td></tr>
<tr><td>4</td><td>1.98</td></tr>
<tr><td>5</td><td>2.19</td></tr>
<tr><td>6</td><td>2.71</td></tr>
<tr><td>7</td><td>2.88</td></tr>
<tr><td>8</td><td>4.15</td></tr>
<tr><td>9</td><td>4.32</td></tr>
<tr><td>A</td><td>4.64</td></tr>
<tr><td>B</td><td>4.79</td></tr>
<tr><td>C</td><td>5.20</td></tr>
<tr><td>D</td><td>5.34</td></tr>
<tr><td>E</td><td>5.54</td></tr>
<tr><td>F</td><td>5.67</td></tr>
</table>
[3:0]: Reserved. Tie these inputs to 4'hF.</td></tr>
</table>

Setting the RX Equalization

This section describes how the AGC, DFE, and CTLE are configured.

AGC

The AGC is auto-adapting.

DFE

The DFE is auto-adapting but requires some training control parameters to be set. For modes that use the internal 8B/10B and PRBS blocks, DFE_TRAIN_CTRL_LANE<n>[15:13] = 100. For modes that use the internal 64B/66B blocks, DFE_TRAIN_CTRL_LANE<n>[15:13] = 001.

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The DFE train limit needs to be set for both modes to determine the number of consecutive error-free multiple 1K symbols. Table 4-5 provides the guidelines for various datapath modes.

For the Raw mode, DFE_TRAIN_CTRL_LANE<n>[15:13] = `010`. The DFE train limit is ignored in this mode.

CTLE

The CTLE has static settings that must be set manually. The CTLE peaking is centered around 2 GHz to 2.5 GHz and is meant to compensate for the attenuation in the low- to mid-frequency band. The DFE compensates for the attenuation in the higher frequencies. RX_CTLE_CTRL_LANE0<n>[7:4] should be set based on the loss of the channel at 2 GHz to 2.5 GHz.

RX CDR

Functional Description

The RX clock data recovery (CDR) circuit in each GTH transceiver extracts the recovered clock and data from an incoming data stream. Figure 4-3 illustrates the architecture of the CDR block. Clock paths are shown with dotted lines for clarity.

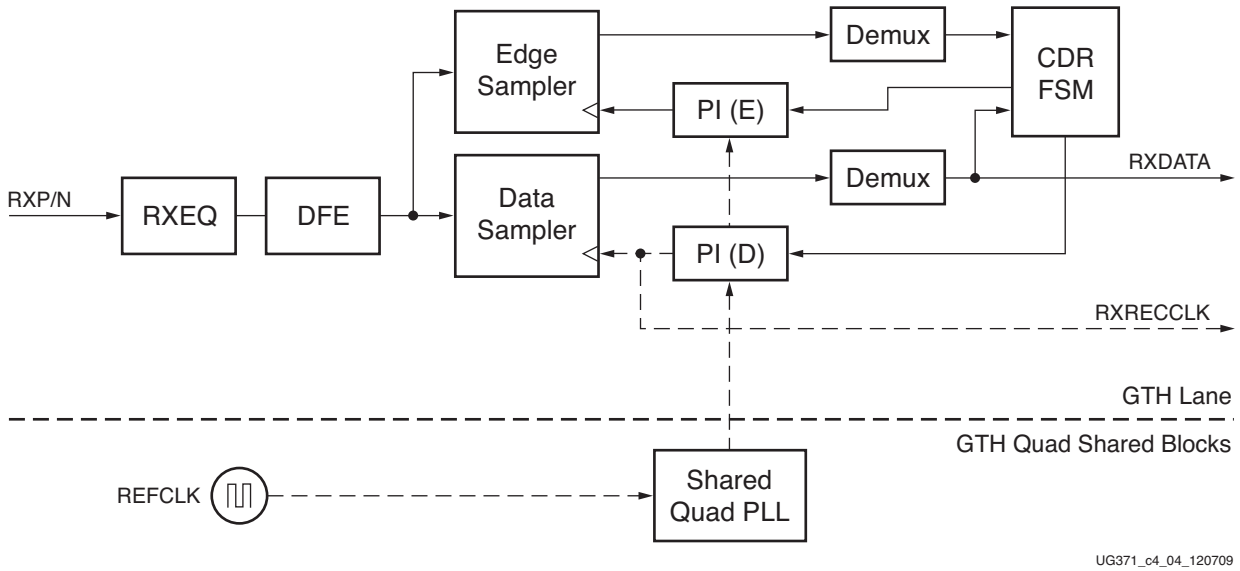

Figure 4-3: **RX CDR Block Diagram**

The GTH transceiver employs a phase rotator CDR architecture. Incoming data first goes through the RX equalization stages. The equalized data is then captured by an edge and a data sampler. The data captured by the data sampler is fed to the downstream RX blocks.

The CDR state machine uses the data from both the edge and data samplers to determine the phase of the incoming data stream and to control the phase interpolators (PIs). The phase for the edge sampler is locked to the transition region of the data stream while the phase of the data sampler is positioned in the middle of the data eye. Figure 4-4 shows the CDR sampler positions.

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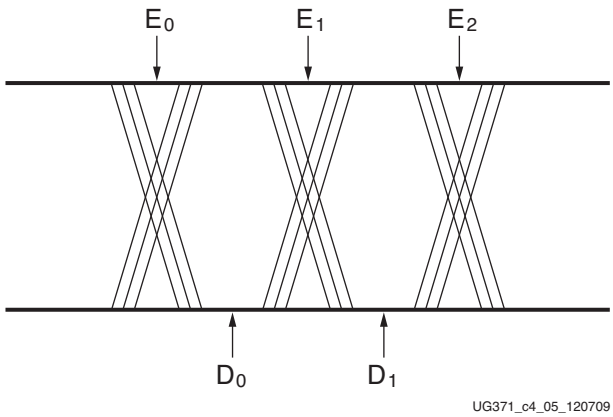

Figure 4-4: **CDR Sampler Positions**

The shared Quad PLL provides a base clock to the phase interpolator. The phase interpolator in term produces fine, evenly spaced sampling phases to allow the CDR state machine to have fine phase control. The CDR state machine can track an incoming data stream with a frequency offset, usually no more than ±100 PPM, from the local PLL reference clock.

Ports and Attributes

There are no ports in the CDR block.

Table 4-6 defines the RX CDR attributes.

Table 4-6: **RX CDR Attributes**

Attribute	Type	Description
RX_CDR_CTRL0_LANE0 RX_CDR_CTRL0_LANE1 RX_CDR_CTRL0_LANE2 RX_CDR_CTRL0_LANE3	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
RX_CDR_CTRL1_LANE0 RX_CDR_CTRL1_LANE1 RX_CDR_CTRL1_LANE2 RX_CDR_CTRL1_LANE3	16-bit Hex	Reserved. Tie to `16'h4200`.
RX_CDR_CTRL2_LANE0 RX_CDR_CTRL2_LANE1 RX_CDR_CTRL2_LANE2 RX_CDR_CTRL2_LANE3	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.
RX_LOOP_CTRL_LANE0 RX_LOOP_CTRL_LANE1 RX_LOOP_CTRL_LANE2 RX_LOOP_CTRL_LANE3	16-bit Hex	Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard.

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RX Polarity Control

Functional Description

The GTH RX can invert incoming data using the RX polarity control function. This function is useful in designs where the RXP and RXN signals can be accidentally connected in reverse.

Ports and Attributes

Table 4-7 defines the RX polarity control ports.

Table 4-7: **RX Polarity Control Ports**

Port	Dir	Clock Domain	Description
RXPOLARITY0	In	RXUSERCLKIN0	The RX polarity port is used to invert the polarity of incoming data. `1`: Invert polarity `0`: Regular polarity
RXPOLARITY1		RXUSERCLKIN1	
RXPOLARITY2		RXUSERCLKIN2	
RXPOLARITY3		RXUSERCLKIN3	

Table 4-8 defines the RX polarity control attributes.

Table 4-8: **RX Polarity Control Attributes**

Attribute	Type	Description
PCS_MISC_CFG_0_LANE0 PCS_MISC_CFG_0_LANE1 PCS_MISC_CFG_0_LANE2 PCS_MISC_CFG_0_LANE3	16-bit Hex	This attribute sets the polarity and PRBS configuration. [15:12]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [11]: Invert TX polarity [10]: RX polarity override enable [9]: RX polarity override value [8]: Reset the PRBS error counter when read [7]: Revert bit order of parallel data to serializer/deserializer TX [6]: Revert bit order of parallel data from serializer/deserializer RX [5:0]: Reserved. Tie to `6'h16` when TXRATE=`2'b00` Tie to `6'h17` when TXRATE=`2'b01` Tie to `6'h14` when TXRATE=`2'b10` Tie to `6'h14` when TXRATE=`2'b11`

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Using RX Polarity Control

If the polarity of RXP/RXN needs to be inverted, RXPOLARITY must be tied High. Alternatively, the DRP or management interface can be used to set PCS_MISC_CFG_0_LANE<n>[10:9] to `2'b11`. The register is located in:

- DRP Address
  - PCS_MISC_CFG_0_LANE0: `0x5001`
  - PCS_MISC_CFG_0_LANE1: `0x5101`
  - PCS_MISC_CFG_0_LANE2: `0x5201`
  - PCS_MISC_CFG_0_LANE3: `0x5301`
- Management Interface Address: `0x8001` with MMD Address `0x03`

  Use the Lane Address setting to specify which GTH lane to access.

RX Pattern Checker

Functional Description

The GTH receiver contains a built-in pattern checker block. The checker supports the following PRBS patterns:

- PRBS7
- PRBS9
- PRBS11
- PRBS23
- PRBS31

In 64B/66B mode (for example, when the GTH transceiver is configured with the 10GBASE-R protocol), the checker is forced into PRBS31 mode when PRBS31 test pattern mode is enabled.

The PRBS checker module implements a 32-bit error counter and a 48-bit timer. The error counter and timer function as follows:

- The first read of any error counter/timer register latches both the error counter/timer in shadow flops.
- If the read was of an error counter and clear-on-read is on, both the timer and error counter are cleared.
- Reads of just the timer register (i.e., without first reading the error counter) do not clear the error count/timer, even if clear-on-read mode is on.
- Subsequent reads from error counter/timer addresses greater than the previous read address only read the shadow flops, do not read the actual state of the error counter/timer, and do not clear the error counter timer.
- Subsequent reads from error counter/timer addresses equal to or less than the read of the previous error counter/timer start the process over.

The error and sample counters saturate when they reach the maximum value.

In pattern check mode, data does not appear on RXDATA ports.

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Ports and Attributes

Table 4-9 defines the RX pattern checker ports.

Table 4-9: **RX Pattern Checker Ports**

Port	Dir	Clock Domain	Description
RXCODEERR0[7:0] RXCODEERR1[7:0] RXCODEERR2[7:0] RXCODEERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate an error occurred on RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs indicate that RXDATA<n> is the result of an 8B/10B code error. RXCODEERR<n>[7] corresponds to RXDATA<n>[63:56] RXCODEERR<n>[6] corresponds to RXDATA<n>[55:48] RXCODEERR<n>[5] corresponds to RXDATA<n>[47:40] RXCODEERR<n>[4] corresponds to RXDATA<n>[39:32] RXCODEERR<n>[3] corresponds to RXDATA<n>[31:24] RXCODEERR<n>[2] corresponds to RXDATA<n>[23:16] RXCODEERR<n>[1] corresponds to RXDATA<n>[15:8] RXCODEERR<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: RXCODEERR<n>[0] indicates a 64B/66B code error. RXCODEERR<n>[7:1] are not used for this mode. Raw mode: These outputs are used as part of RXDATA<n>[79:72].

Table 4-10 defines the RX pattern checker attributes.

Table 4-10: **RX Pattern Checker Attributes**

Attribute	Type	Description
PCS_MISC_CFG_0_LANE0 PCS_MISC_CFG_0_LANE1 PCS_MISC_CFG_0_LANE2 PCS_MISC_CFG_0_LANE3	16-bit Hex	This attribute sets the polarity and PRBS configuration. [15:12]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [11]: Invert TX polarity [10]: RX polarity override enable [9]: RX polarity override value [8]: Reset the PRBS error counter when read [7]: Revert bit order of parallel data to serializer/deserializer TX [6]: Revert bit order of parallel data from serializer/deserializer RX [5:0]: Reserved. Tie to `6'h16` when TXRATE=`2'b00` Tie to `6'h17` when TXRATE=`2'b01` Tie to `6'h14` when TXRATE=`2'b10` Tie to `6'h14` when TXRATE=`2'b11`

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Table 4-10: **RX Pattern Checker Attributes *(Cont'd)***

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 16-bit 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 4-10: **RX Pattern Checker Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. These bits vary by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: These bits control the datapath resets. They vary by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
PRBS_CFG_LANE0 PRBS_CFG_LANE1 PRBS_CFG_LANE2 PRBS_CFG_LANE3	16-bit Hex	This attribute sets the PRBS data width. [15:4]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [3:2]: PRBS generate width `2'b11`: 20b `2'b10`: 16b Others: Reserved [1:0]: PRBS checker width `2'b11`: 20b `2'b10`: 16b Others: Reserved

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Table 4-11 defines the RX pattern checker registers.

Table 4-11: **RX Pattern Checker Registers (Read Only)**

Register Name[1]	Type	Description
PRBS_ERR_CNT0_LANE<n>	16-bit Hex	PRBS error counter [31:16]. Counter for PRBS or 8B/10B errors.
PRBS_ERR_CNT1_LANE<n>	16-bit Hex	PRBS error counter [15:0]. Counter for PRBS or 8B/10B errors.
PRBS_TIMER_0_LANE<n>	16-bit Hex	PRBS timer [47:32]. Timer for PRBS mode testing or monitoring.
PRBS_TIMER_1_LANE<n>	16-bit Hex	PRBS timer [31:16]. Timer for PRBS mode testing or monitoring.
PRBS_TIMER_2_LANE<n>	16-bit Hex	PRBS timer [15:0]. Timer for PRBS mode testing or monitoring.

Notes:

1. The DRP or the Management Interface must be used to access these registers.

Using RX Pattern Checker

For the read-only registers, the DRP or management interface can be used for monitoring the PRBS error counter and the timer for PRBS testing.

- DRP Address
  - PRBS_ERR_CNT0_LANE0: `0x5002`
  - PRBS_ERR_CNT0_LANE1: `0x5102`
  - PRBS_ERR_CNT0_LANE2: `0x5202`
  - PRBS_ERR_CNT0_LANE3: `0x5302`
  - PRBS_ERR_CNT1_LANE0: `0x5003`
  - PRBS_ERR_CNT1_LANE1: `0x5103`
  - PRBS_ERR_CNT1_LANE2: `0x5203`
  - PRBS_ERR_CNT1_LANE3: `0x5303`
  - PRBS_TIMER_0_LANE0: `0x5004`
  - PRBS_TIMER_0_LANE1: `0x5104`
  - PRBS_TIMER_0_LANE2: `0x5204`
  - PRBS_TIMER_0_LANE3: `0x5304`
  - PRBS_TIMER_1_LANE0: `0x5005`
  - PRBS_TIMER_1_LANE1: `0x5105`
  - PRBS_TIMER_1_LANE2: `0x5205`
  - PRBS_TIMER_1_LANE3: `0x5305`
  - PRBS_TIMER_2_LANE0: `0x5006`
  - PRBS_TIMER_2_LANE1: `0x5106`
  - PRBS_TIMER_2_LANE2: `0x5206`
  - PRBS_TIMER_2_LANE3: `0x5306`

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- Management Interface Address:

  The Lane Address setting is used to specify which GTH lane to access:

  - PRBS_ERR_CNT0: 0x8002 with MMD Address 0x03
  - PRBS_ERR_CNT1: 0x8003 with MMD Address 0x03
  - PRBS_TIMER_0: 0x8004 with MMD Address 0x03
  - PRBS_TIMER_1: 0x8005 with MMD Address 0x03
  - PRBS_TIMER_2: 0x8006 with MMD Address 0x03

RX Raw Mode

Functional Description

The GTH transceiver provides another datapath mode for non-encoded applications or when the user wants to bypass the 8B/10B and 64B/66B blocks.

Ports and Attributes

Table 4-12 defines the RX raw mode ports.

Table 4-12: **RX Raw Mode Ports**

Port	Dir	Clock Domain	Description
RXCODEERR0[7:0] RXCODEERR1[7:0] RXCODEERR2[7:0] RXCODEERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate an error occurred on RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs indicate that RXDATA<n> is the result of an 8B/10B code error. RXCODEERR<n>[7] corresponds to RXDATA<n>[63:56] RXCODEERR<n>[6] corresponds to RXDATA<n>[55:48] RXCODEERR<n>[5] corresponds to RXDATA<n>[47:40] RXCODEERR<n>[4] corresponds to RXDATA<n>[39:32] RXCODEERR<n>[3] corresponds to RXDATA<n>[31:24] RXCODEERR<n>[2] corresponds to RXDATA<n>[23:16] RXCODEERR<n>[1] corresponds to RXDATA<n>[15:8] RXCODEERR<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: RXCODEERR<n>[0] indicates a 64B/66B code error. RXCODEERR<n>[7:1] are not used for this mode. Raw mode: These outputs are used as part of RXDATA<n>[79:72].

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Table 4-12: **RX Raw Mode Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXCTRL0[7:0] RXCTRL1[7:0] RXCTRL2[7:0] RXCTRL3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate the status of RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs are asserted when RXDATA<n> is an 8B/10B K character. RXCTRL<n>[7] corresponds to RXDATA<n>[63:56] RXCTRL<n>[6] corresponds to RXDATA<n>[55:48] RXCTRL<n>[5] corresponds to RXDATA<n>[47:40] RXCTRL<n>[4] corresponds to RXDATA<n>[39:32] RXCTRL<n>[3] corresponds to RXDATA<n>[31:24] RXCTRL<n>[2] corresponds to RXDATA<n>[23:16] RXCTRL<n>[1] corresponds to RXDATA<n>[15:8] RXCTRL<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: These outputs are 64B/66B control bits. Raw mode: These outputs are used as part of RXDATA<n>[71:64].
RXDATA0[63:0] RXDATA1[63:0] RXDATA2[63:0] RXDATA3[63:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This output bus is the receive data bus of the receive interface to the FPGA.
RXSLIP0 RXSLIP1 RXSLIP2 RXSLIP3	In	Async	This port is used in raw mode for the barrel shifter operation to advance the bit alignment position. When RXSLIP<n> is asserted, the alignment position is incremented by one bit subject to the maximum alignment position for the given receiver lane width. It wraps back to 0 after adjusting to the maximum alignment position.

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Table 4-13 defines the RX raw mode attributes.

Table 4-13: **RX Raw Mode Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets the PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 4-13: **RX Raw Mode Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. These bits vary by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from theVirtex-6 FPGA GTH Transceiver Wizard. [1:0]: These bits control the datapath resets. They vary by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
RX_FABRIC_WIDTH0 RX_FABRIC_WIDTH1 RX_FABRIC_WIDTH2 RX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the receiver. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

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Table 4-14 defines the RX raw mode read-only registers.

Table 4-14: **RX Raw Mode Read-only Registers**

Read-only Registers	Type	Description
RAW_SHIFT_MON_LANE0 RAW_SHIFT_MON_LANE1 RAW_SHIFT_MON_LANE2 RAW_SHIFT_MON_LANE3	16-bit Hex	This register is used for the barrel shifter from the raw data mode. [15:5]: Reserved. [4:0]: Bit position of the LSB of RX data in the serial-to-parallel data stream.

Enabling Raw Mode

Follow these steps to enable the raw mode in the GTH receiver:

1. If the receive fabric data width is configured to 16 bits, 32 bits, or 64 bits:
   a. Set PCS_MODE_LANE<n>[7:4] to `4'b1010`.
   b. Set PCS_RESET_LANE<n> to `0xFF3B`.
   c. Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
   d. Set RX_FABRIC_WIDTH<n> to "16", "32", or "64."
2. If the receive fabric data width is configured to 20 bits, 40 bits, or 80 bits:
   a. Set PCS_MODE_LANE<n>[7:4] to `4'b1011`.
   b. Set PCS_RESET_LANE<n> to `0xFF3B`.
   c. Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
   d. Set RX_FABRIC_WIDTH<n> to "20", "40", or "80."

Using the Barrel Shifter

The raw data mode provides control of the raw bit alignment position to the user. The user must drive RXSLIP port High to advance the bit alignment position. The bit alignment position starts at 0 upon reset and increments by one bit on every positive edge of RXSLIP.

The bit alignment position of the barrel shifter can be monitored through either the DRP interface or the management interface by accessing the RAW_SHIFT_MON_LANE<n>[4:0] register:

- DRP Address
  - RAW_SHIFT_MON_LANE0: `0x500E`
  - RAW_SHIFT_MON_LANE1: `0x510E`
  - RAW_SHIFT_MON_LANE2: `0x520E`
  - RAW_SHIFT_MON_LANE3: `0x530E`
- Management Interface Address: `0x800E` with MMD Address `0x03`

  Use the Lane Address setting to specify which GTH lane to access.

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RX 10 Gigabit Ethernet 64B/66B Block

Functional Description

The GTH transceiver implements the 64B/66B block based on IEEE 802.3-2008 Clause 49, "Physical Sublayer (PCS) for 64B/66B, type 10GBASE-R." The RX 10 Gb Ethernet 64B/66B block includes the block synchronization, the gearbox, and the descrambler.

Ports and Attributes

Table 4-15 defines the RX 10 Gb Ethernet 64B/66B block ports.

Table 4-15: **RX 10 Gb Ethernet 64B/66B Block Ports**

Port	Dir	Clock Domain	Description
RXCODEERR0[7:0] RXCODEERR1[7:0] RXCODEERR2[7:0] RXCODEERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate an error occurred on RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs indicate that RXDATA<n> is the result of an 8B/10B code error. RXCODEERR<n>[7] corresponds to RXDATA<n>[63:56] RXCODEERR<n>[6] corresponds to RXDATA<n>[55:48] RXCODEERR<n>[5] corresponds to RXDATA<n>[47:40] RXCODEERR<n>[4] corresponds to RXDATA<n>[39:32] RXCODEERR<n>[3] corresponds to RXDATA<n>[31:24] RXCODEERR<n>[2] corresponds to RXDATA<n>[23:16] RXCODEERR<n>[1] corresponds to RXDATA<n>[15:8] RXCODEERR<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: RXCODEERR<n>[0] indicates a 64B/66B code error. RXCODEERR<n>[7:1] are not used for this mode. Raw mode: These outputs are used as part of RXDATA<n>[79:72].

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Table 4-15: **RX 10 Gb Ethernet 64B/66B Block Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXCTRL0[7:0] RXCTRL1[7:0] RXCTRL2[7:0] RXCTRL3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate the status of RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs are asserted when RXDATA<n> is an 8B/10B K character. RXCTRL<n>[7] corresponds to RXDATA<n>[63:56] RXCTRL<n>[6] corresponds to RXDATA<n>[55:48] RXCTRL<n>[5] corresponds to RXDATA<n>[47:40] RXCTRL<n>[4] corresponds to RXDATA<n>[39:32] RXCTRL<n>[3] corresponds to RXDATA<n>[31:24] RXCTRL<n>[2] corresponds to RXDATA<n>[23:16] RXCTRL<n>[1] corresponds to RXDATA<n>[15:8] RXCTRL<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: These outputs are 64B/66B control bits. Raw mode: These outputs are used as part of RXDATA<n>[71:64].
RXDATA0[63:0] RXDATA1[63:0] RXDATA2[63:0] RXDATA3[63:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This output bus is the receive data bus of the receive interface to the FPGA.

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Table 4-16 defines the RX 10 Gb Ethernet 64B/66B block attributes.

Table 4-16: **RX 10 Gb Ethernet 64B/66B Block Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [10:8]: PRBS checker mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [7:4]: PCS RX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved [3:0]: PCS TX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved

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Table 4-16: **RX 10 Gb Ethernet 64B/66B Block Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	This attribute controls the datapath resets. These bits vary by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: These bits control the datapath resets. They vary by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
RX_FABRIC_WIDTH0 RX_FABRIC_WIDTH1 RX_FABRIC_WIDTH2 RX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the receiver. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

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Enabling 64B/66B Mode

Follow these steps to enable the 64B/66B mode in the GTH receiver:

1. Set PCS_MODE_LANE<n>[7:4] to `4'b0001`.
2. Set PCS_RESET_LANE<n> to `0xF3FE`.
3. Set PCS_RESET_1_LANE<n>[1:0] to `2'b10`.
4. Set RX_FABRIC_WIDTH<n> to "6466."

RX 8B/10B Block

Functional Description

The GTH transceiver includes an 8B/10B decoder to decode RX data without consuming FPGA resources. The decoder includes status signals to indicate errors and incoming control sequences.

Serial data must be aligned to symbol boundaries before it can be used as parallel data. To make alignment possible, transmitters send a recognizable sequence, usually called a comma. The receiver searches for the comma in the incoming data. When it finds a comma, the receiver moves the comma to a byte boundary so the received parallel words match the transmitted parallel words. The receiver's 8B/10B block includes an alignment block that detects the following commas: K28.1, K.28.5, and K28.7.

Ports and Attributes

Table 4-17 defines RX 8B/10B block ports.

Table 4-17: **RX 8B/10B Block Ports**

Port	Dir	Clock Domain	Description
RXCODEERR0[7:0] RXCODEERR1[7:0] RXCODEERR2[7:0] RXCODEERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate an error occurred on RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs indicate that RXDATA<n> is the result of an 8B/10B code error. RXCODEERR<n>[7] corresponds to RXDATA<n>[63:56] RXCODEERR<n>[6] corresponds to RXDATA<n>[55:48] RXCODEERR<n>[5] corresponds to RXDATA<n>[47:40] RXCODEERR<n>[4] corresponds to RXDATA<n>[39:32] RXCODEERR<n>[3] corresponds to RXDATA<n>[31:24] RXCODEERR<n>[2] corresponds to RXDATA<n>[23:16] RXCODEERR<n>[1] corresponds to RXDATA<n>[15:8] RXCODEERR<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: RXCODEERR<n>[0] indicates a 64B/66B code error. RXCODEERR<n>[7:1] are not used for this mode. Raw mode: These outputs are used as part of RXDATA<n>[79:72].

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Table 4-17: **RX 8B/10B Block Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXCTRL0[7:0] RXCTRL1[7:0] RXCTRL2[7:0] RXCTRL3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate the status of RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs are asserted when RXDATA<n> is an 8B/10B K character. RXCTRL<n>[7] corresponds to RXDATA<n>[63:56] RXCTRL<n>[6] corresponds to RXDATA<n>[55:48] RXCTRL<n>[5] corresponds to RXDATA<n>[47:40] RXCTRL<n>[4] corresponds to RXDATA<n>[39:32] RXCTRL<n>[3] corresponds to RXDATA<n>[31:24] RXCTRL<n>[2] corresponds to RXDATA<n>[23:16] RXCTRL<n>[1] corresponds to RXDATA<n>[15:8] RXCTRL<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: These outputs are 64B/66B control bits. Raw mode: These outputs are used as part of RXDATA<n>[71:64].
RXDATA0[63:0] RXDATA1[63:0] RXDATA2[63:0] RXDATA3[63:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This output bus is the receive data bus of the receive interface to the FPGA.
RXDISPERR0[7:0] RXDISPERR1[7:0] RXDISPERR2[7:0] RXDISPERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	Used only for 8B/10B mode. These outputs indicate a disparity error occurred on RXDATA<n>. RXDISPERR<n>[7] corresponds to RXDATA<n>[63:56] RXDISPERR<n>[6] corresponds to RXDATA<n>[55:48] RXDISPERR<n>[5] corresponds to RXDATA<n>[47:40] RXDISPERR<n>[4] corresponds to RXDATA<n>[39:32] RXDISPERR<n>[3] corresponds to RXDATA<n>[31:24] RXDISPERR<n>[2] corresponds to RXDATA<n>[23:16] RXDISPERR<n>[1] corresponds to RXDATA<n>[15:8] RXDISPERR<n>[0] corresponds to RXDATA<n>[7:0]
RXENCOMMADET0 RXENCOMMADET1 RXENCOMMADET2 RXENCOMMADET3	In	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This input activates the comma detection and alignment circuit for 8B/10B mode.
RXVALID0[7:0] RXVALID1[7:0] RXVALID2[7:0] RXVALID3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These status outputs indicate which bytes are valid used in 8B/10B mode only. RXVALID<n>[7] corresponds to RXDATA<n>[63:56] RXVALID<n>[6] corresponds to RXDATA<n>[55:48] RXVALID<n>[5] corresponds to RXDATA<n>[47:40] RXVALID<n>[4] corresponds to RXDATA<n>[39:32] RXVALID<n>[3] corresponds to RXDATA<n>[31:24] RXVALID<n>[2] corresponds to RXDATA<n>[23:16] RXVALID<n>[1] corresponds to RXDATA<n>[15:8] RXVALID<n>[0] corresponds to RXDATA<n>[7:0]

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Table 4-18 defines the RX 8B/10B block attributes.

Table 4-18: **RX 8B/10B Block Attributes**

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [10:8]: PRBS checker mode `000`: None `001`: PRBS7 `010`: PRBS9 `011`: PRBS11 `100`: PRBS23 `101`: PRBS31 Others: Reserved [7:4]: PCS RX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved [3:0]: PCS TX mode `0000`: Zero `0001`: 64B/66B `0111`: 8B/10B `1010`: 16-bit raw data `1011`: 20-bit raw data `1100`: PRBS Others: Reserved

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Table 4-18: **RX 8B/10B Block Attributes *(Cont'd)***

Attribute	Type	Description
PCS_RESET_LANE0 PCS_RESET_LANE1 PCS_RESET_LANE2 PCS_RESET_LANE3	16-bit Hex	Defaults to `16'h0000`. This attribute controls the datapath resets. These bits vary by mode: 64B/66B: `0xF3FE` 8B/10B: `0xFC5B` Raw: `0xFF3B` PRBS: `0xFFCE` Default: `0xFFFF` [15:12]: Reserved [11]: Reset 64B/66B receive [10]: Reset 64B/66B transmit [9]: Reset 8B/10B receive [8]: Reset 8B/10B transmit [7]: Reset RX FIFO [6]: Reset RX raw shift pointer [5]: Reset PRBS checker [4]: Reset PRBS generator [3]: Reserved [2]: Reset TX FIFO [1]: Reset RX loopback FIFO [0]: Reserved
PCS_RESET_1_LANE0 PCS_RESET_1_LANE1 PCS_RESET_1_LANE2 PCS_RESET_1_LANE3	16-bit Hex	[15:2]: Reserved. Use the recommended values from the Virtex-6 FPGA GTH Transceiver Wizard. [1:0]: These bits control the datapath resets. They vary by mode: 64B/66B: `2'b10` 8B/10B: `2'b00` Raw: `2'b00` PRBS: `2'b10` Default: `2'b11`
RX_FABRIC_WIDTH0 RX_FABRIC_WIDTH1 RX_FABRIC_WIDTH2 RX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the receiver. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

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Enabling 8B/10B Mode

Follow these steps to enable the 8B/10B mode in the GTH receiver:

1. Set PCS_MODE_LANE<n>[7:4] to `4'b0111`.
2. Set PCS_RESET_LANE<n> to `0xFC5B`.
3. Set PCS_RESET_1_LANE<n>[1:0] to `2'b00`.
4. Set RX_FABRIC_WIDTH<n> to “16”, “32”, or “64” depending on the application.

Using Comma Alignment

To enable the comma alignment block, the RXENCOMMADET port must be asserted. When comma detection is enabled, the decoder sees a comma character at any bit position. It tries to find the comma characters K28.1, K.28.5, and K28.7. When any of those comma characters is found, the decoder locks to it. When RXENCOMMADET is deasserted, the current state of the symbol lock remains unchanged.

If the comma characters can arrive in both even and odd byte positions, comma detection should be disabled when symbol lock is achieved. The comma detection logic always attempts to align comma characters to the least significant byte.

FPGA RX Interface

Functional Description

The FPGA receives RX data from the GTH receiver through the FPGA RX interface. Data is read from the RXDATA port on the positive edge of RXUSERCLKIN. The width of the port can be configured depending on the mode chosen (see Table 4-19).

Table 4-19: **FPGA RX Interface Port Width**

Mode	Port Width
8B/10B mode	• 16 bits • 32 bits • 64 bits
64B/66 mode	• 64 bits
Raw mode	• 16 bits • 20 bits • 32 bits • 40 bits • 64 bits • 80 bits

The rate of the parallel clock, RXUSERCLKIN, at the interface is determined by the RX line rate, the width of the RXDATA port, and whether or not 8B/10B mode is used. A block inside the PCS handles the mapping of the internal data width to the fabric data width selected in the design.

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A data width converter block is included in the receive datapath. This block includes:

- A clock generator that takes the internal PCS clock, derived from the recovered clock, and generates RXUSERCLKOUT to the FPGA logic based on the external data width selected
- A four-byte-deep FIFO that handles the phase difference between the internal PCS clock and the external user clock
- A data width converter between the internal PCS data interface and the external data interface to the FPGA logic

The PCS_MODE_LANE<n>[7:4] attribute configures the internal data width, and the RX_FABRIC_WIDTH<n> attribute configures the external data width. Table 4-20 shows how the interface width for the TX datapath is selected.

Table 4-20: **FPGA RX Interface Datapath Configuration**

RX Data Mode	Internal PCS Data Width	Fabric Interface Data Width	PCS_MODE_LANE<n>[7:4]	RX_FABRIC_WIDTH<n>
8B/10B	20 bits	16 bits	0111	16
	20 bits	32 bits	0111	32
	20 bits	64 bits	0111	64
64B/66B	64 bits	64 bits	0001	6466
Raw	16 bits	16 bits	1010	16
	16 bits	32 bits	1010	32
	16 bits	64 bits	1010	64
	20 bits	20 bits	1011	20
	20 bits	40 bits	1011	40
	20 bits	80 bits	1011	80

Figure 3-1, page 79 is a block diagram of the PCS logic. It shows the receive datapath with the different modes and the data converter block.

There are certain restrictions that the user must consider when configuring the fabric data width:

- The fabric interface data width must be the same for both the transmitter and receiver within a GTH lane.
- The data mode must be the same for both the transmitter and receiver within a GTH lane.
- The data mode must be the same on all four GTH lanes within a Quad.

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Ports and Attributes

Table 4-21 defines the FPGA RX interface ports.

Table 4-21: **FPGA RX Interface Ports**

Port	Dir	Clock Domain	Description
GTHX4LANE	In	Async	When this port is asserted, GTH lanes 0, 1, 2, and 3 are configured into a single x4 link.
RXBUFRESET0 RXBUFRESET1 RXBUFRESET2 RXBUFRESET3	In	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This port resets the buffer inside the RX data converter. Both the internal RX clock and RXUSERCLKIN<n> must be stable before a reset can be applied to the buffer.
RXCODEERR0[7:0] RXCODEERR1[7:0] RXCODEERR2[7:0] RXCODEERR3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate an error occurred on RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs indicate that RXDATA<n> is the result of an 8B/10B code error. RXCODEERR<n>[7] corresponds to RXDATA<n>[63:56] RXCODEERR<n>[6] corresponds to RXDATA<n>[55:48] RXCODEERR<n>[5] corresponds to RXDATA<n>[47:40] RXCODEERR<n>[4] corresponds to RXDATA<n>[39:32] RXCODEERR<n>[3] corresponds to RXDATA<n>[31:24] RXCODEERR<n>[2] corresponds to RXDATA<n>[23:16] RXCODEERR<n>[1] corresponds to RXDATA<n>[15:8] RXCODEERR<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: RXCODEERR<n>[0] indicates a 64B/66B code error. RXCODEERR<n>[7:1] are not used for this mode. Raw mode: These outputs are used as part of RXDATA<n>[79:72].
RXCTRL0[7:0] RXCTRL1[7:0] RXCTRL2[7:0] RXCTRL3[7:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	These outputs indicate the status of RXDATA<n> or they are used as an extension of RXDATA<n> depending on the mode selected in the receive datapath: 8B/10B: These outputs are asserted when RXDATA<n> is an 8B/10B K character. RXCTRL<n>[7] corresponds to RXDATA<n>[63:56] RXCTRL<n>[6] corresponds to RXDATA<n>[55:48] RXCTRL<n>[5] corresponds to RXDATA<n>[47:40] RXCTRL<n>[4] corresponds to RXDATA<n>[39:32] RXCTRL<n>[3] corresponds to RXDATA<n>[31:24] RXCTRL<n>[2] corresponds to RXDATA<n>[23:16] RXCTRL<n>[1] corresponds to RXDATA<n>[15:8] RXCTRL<n>[0] corresponds to RXDATA<n>[7:0] 64B/66B: These outputs are 64B/66B control bits. Raw mode: These outputs are used as part of RXDATA<n>[71:64].

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Table 4-21: **FPGA RX Interface Ports *(Cont'd)***

Port	Dir	Clock Domain	Description
RXDATA0[63:0] RXDATA1[63:0] RXDATA2[63:0] RXDATA3[63:0]	Out	RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	This output bus is the receive data bus of the receive interface to the FPGA.
RXUSERCLKIN0 RXUSERCLKIN1 RXUSERCLKIN2 RXUSERCLKIN3	In	N/A	This port provides a clock for the internal receiver PCS datapath. It is a buffered version of RXUSERCLKOUT<n>.
RXUSERCLKOUT0 RXUSERCLKOUT1 RXUSERCLKOUT2 RXUSERCLKOUT3	Out	N/A	This output is the recovered clock based on the receiver data bus width and RXRATE<n>. This clock is used to drive RXUSERCLKIN<n> through a buffer.

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Table 4-22 defines the FPGA RX interface attributes.

Table 4-22: **FPGA RX Interface Attributes**

Attribute	Type	Description
BUFFER_CONFIG_LANE0 BUFFER_CONFIG_LANE1 BUFFER_CONFIG_LANE2 BUFFER_CONFIG_LANE3	16-bit Hex	Defaults to `16'h4004`. [15:4]: TX_BUFFER_CONFIG[11:0] read pointer adjustment for TX buffer in the data converter. • For auto adjustment mode, TX_BUFFER_CONFIG[11:0] = `12'h400`. • For manual adjustment mode, TX_BUFFER_CONFIG[11:0] settings depend on TX_FABRIC_WIDTH and if the GTH transceivers within a Quad are configured as a x4 link (GTHX4LANE = `1'b1`): • x4 (GTHX4LANE = `1'b1`): [TX_FABRIC_WIDTH] = [TX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `12'h0A4` "32" (DRP value `3'b011`): `12'h394` "40" (DRP value `3'b101`): `12'h394` "64" (DRP value `3'b010`): `12'h250` "80" (DRP value `3'b110`): `12'h250` "6466" (DRP value `3'b111`): `12'h0A4` • x1 (GTHX4LANE = `1'b0`): [TX_FABRIC_WIDTH] = [TX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `12'h23C` "32" (DRP value `3'b011`): `12'h0E8` "40" (DRP value `3'b101`): `12'h0E8` "64" (DRP value `3'b010`): `12'h3A8` "80" (DRP value `3'b110`): `12'h3A8` "6466" (DRP value `3'b111`): `12'h23C` [4:0]: RX_BUFFER_CONFIG[3:0] read pointer adjustment for RX buffer in the data converter. • For auto adjustment mode, RX_BUFFER_CONFIG[3:0] = `0100`. • For manual adjustment mode, RX_BUFFER_CONFIG[3:0] settings depend on RX_FABRIC_WIDTH: [RX_FABRIC_WIDTH] = [RX_BUFFER_CONFIG] "16" or "20" (DRP value `3'b000`): `4'b0001` "32" (DRP value `3'b011`): `4'b0000` "40" (DRP value `3'b101`): `4'b0000` "64" (DRP value `3'b010`): `4'b0000` "80" (DRP value `3'b110`): `4'b0000` "6466" (DRP value `3'b111`): `4'b0001`

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Table 4-22: **FPGA RX Interface Attributes *(Cont'd)***

Attribute	Type	Description
PCS_MODE_LANE0 PCS_MODE_LANE1 PCS_MODE_LANE2 PCS_MODE_LANE3	16-bit Hex	This attribute sets PCS mode. [15]: Loopback serializer/deserializer RX to serializer/deserializer TX [14]: Loopback PCS TX to PCS RX [13:11]: PRBS generator mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [10:8]: PRBS checker mode 000: None 001: PRBS7 010: PRBS9 011: PRBS11 100: PRBS23 101: PRBS31 Others: Reserved [7:4]: PCS RX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved [3:0]: PCS TX mode 0000: Zero 0001: 64B/66B 0111: 8B/10B 1010: 16-bit raw data 1011: 20-bit raw data 1100: PRBS Others: Reserved

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Table 4-22: **FPGA RX Interface Attributes *(Cont'd)***

Attribute	Type	Description
RX_FABRIC_WIDTH0 RX_FABRIC_WIDTH1 RX_FABRIC_WIDTH2 RX_FABRIC_WIDTH3	Integer	This attribute sets the mapping of the internal data width (PCS) to the external data width (fabric) for the receiver. Valid settings are: "16" (DRP value `3'b000`): PCS to Fabric 1:1 "20" (DRP value `3'b000`): PCS to Fabric 1:1 "32" (DRP value `3'b011`): PCS to Fabric 1:2 32 bits "40" (DRP value `3'b101`): PCS to Fabric 1:2 40 bits "64" (DRP value `3'b010`): PCS to Fabric 1:4 64 bits "80" (DRP value `3'b110`): PCS to Fabric 1:4 80 bits "6466" (DRP value `3'b111`): 64B/66B mode

Receive Clocking

The GTH transceiver provides a parallel clock to the FPGA RX interface, RXUSERCLKOUT. The user design must drive this clock to RXUSERCLKIN through either a BUFG or a BUFR. RXUSERCLKIN is the main synchronization clock for all signals into the RX side of the GTH transceiver.

Figure 4-5 is a diagram of the FPGA RX interface clocking.

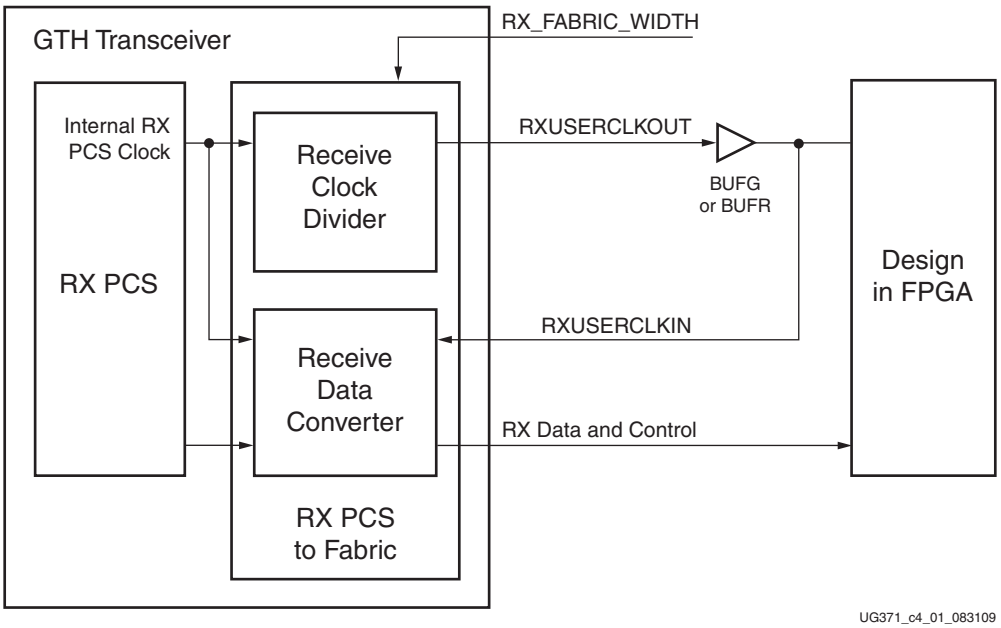

Figure 4-5: **FPGA RX Interface Clocking**

The user must consider these restrictions for the receive clocking on the GTH transceiver:

- Within a GTH Quad, the four receivers can share one BUFG/BUFR as long as the line rate, fabric data width, decoding, and the clock source on the four links partner transmitting data to the GTH receivers are the same across the four receivers.

  If the four link partners do not share the same clock source, then each GTH receiver must have its own BUFG/BUFR.

- The transmitter cannot use the same clock as the receiver; that is, TXUSERCLKIN and RXUSERCLKIN cannot be sourced from the same clock.

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Configuring the Receiver for Multi-lane Applications

To configure four GTH lanes within a Quad into a single x4 link, the GTHX4LANE port must be tied High. When configured in a single x4 link, a change in the control settings on the master lane also causes the same effect on the slaves, except with the POWERDOWN ports. The POWERDOWN ports of all GTH lanes within a Quad in a x4 link should be driven by the same source.

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Chapter 5

Board Design Guidelines

Overview

This chapter discusses topics related to implementing a design on a printed circuit board (PCB) that uses the Virtex®-6 FPGA GTH transceivers. The GTH transceivers are analog circuits that require special consideration and attention. Besides an understanding of the device pin functionality, an optimal design requires attention to issues such as device interfacing, transmission line impedance and routing, power supply design filtering and distribution, component selection, and PCB layout and stackup design.

Pin Description and Design Guidelines

This section describes the GTH Quad pins and the termination resistor calibration circuit.

GTH Quad Pin Descriptions

Table 5-1 defines the GTH Quad pins.

Table 5-1: **GTH Quad Pin Descriptions**

Pins	Dir	Description
MGTREFCLKP MGTREFCLKN	In (Pad)	MGTREFCLKP and MGTREFCLKN are the differential clock input pin pair for the reference clock of the GTHE1_QUAD primitive.
MGTRXP0/MGTRXN0 MGTRXP1/MGTRXN1 MGTRXP2/MGTRXN2 MGTRXP3/MGTRXN3	In (Pad)	MGTRXPn and MGTRXNn are the differential input pairs for each of the receivers in the GTHE1_QUAD primitive.
MGTTXP0/MGTTXN0 MGTTXP1/MGTTXN1 MGTTXP2/MGTTXN2 MGTTXP3/MGTTXN3	Out (Pad)	MGTTXPn and MGTTXNn are the differential output pairs for each of the transmitters in the GTHE1_QUAD primitive.
MGTRBIAS	In (Pad)	MGTRBIAS provides internal precision current, voltage, and resistor references for the GTH Quad. This pin should be connected to a 1 kΩ resistor with the other terminal of the resistor connected to ground. Refer to Termination Resistor Calibration Circuit.
MGTHAVCC	In (Pad)	MGTHAVCC is an analog supply for internal circuits for the receiver and the transmitter. The nominal voltage is 1.1 V_{DC}

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Table 5-1: **GTH Quad Pin Descriptions *(Cont'd)***

Pins	Dir	Description
MGTHAVCCRX	In (Pad)	MGTHAVCCRX is an analog supply for the PLL and the receiver equalizers. The nominal voltage is 1.1 V_{DC}
MGTHAVTT	In (Pad)	MGTHAVTT is an analog supply for the transmit driver. The nominal voltage is 1.2 V_{DC}
MGTHAVCCPLL	In (Pad)	MGTHAVCCPLL is an analog supply for the reference clock buffer and the PLL. The nominal voltage is 1.8 V_{DC}
MGTHAGND	N/A	MGTHAGND is the ground reference for the GTH transceiver internal circuitry. These pins should be connected to the PCB power supply ground reference plane.

Figure 5-1 shows the power supply pin connections for the GTH Quad. The listed voltages are nominal values. Refer to DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics* for more detailed information.

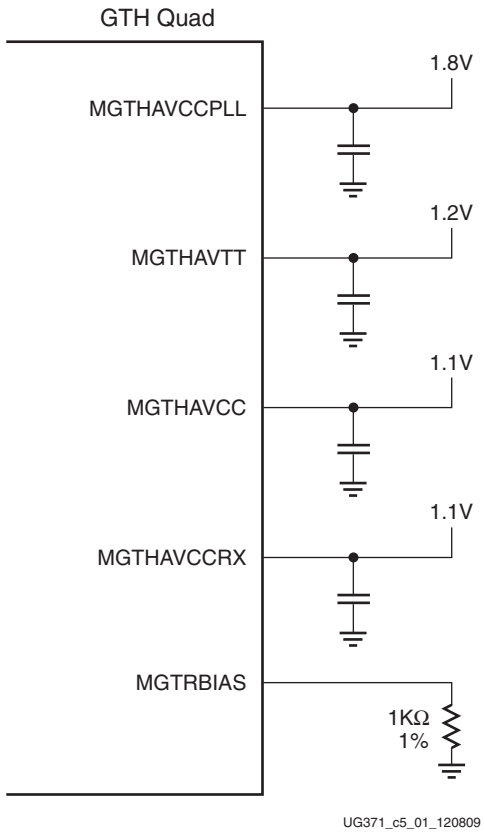

Figure 5-1: **Virtex-6 FPGA GTH Transceiver Power Supply Connections**

Notes relevant to Figure 5-1:

- The voltages shown are nominal values. Refer to DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics* for values and tolerances.
- Capacitor symbols are representative.

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Termination Resistor Calibration Circuit

Each GTH Quad has one resistor bias circuit (RBIAS). The MGTRBIAS pin connects the RBIAS circuit to an external 1 kΩ 1% resistor. For proper operation of the RBIAS circuit, all GTH transceiver analog power supplies (MGTHAVCC, MGTHAVCCRX, MGTHAVCCPLL, and MGTHAVTT) must be present and within the proper tolerance as specified in the *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*.

For reliable operation of the RBIAS circuit, the connection between the RBIAS pin of the FPGA and the pin of the precision resistor must be less than 5 pF and the resistance must be less than 10Ω.

Board Design Guidelines – Analog Power Supply Pins

The GTH Quad analog power supplies, MGTHAVCC, MGTHAVCCRX, MGTHAVCCPLL, and MGTHAVTT have planes inside the package. For some of the packages, there are two planes for each analog power supply. These planes are designated as left and right planes. The orientation of these planes as left and right is based on the bottom view of the package. Some Virtex-6 HXT FPGA's have GTH Quads only on one side of the package, the right side while other HXT FPGAs have GTH Quads on both sides of the package.

The GTH Quads on a side are grouped by their common analog power supply connections. There is a left group of GTH Quads and there is a right group of GTH Quads. For each of the analog power supplies, pins for all of the right GTH Quads are connected to common power planes inside the package. Similarly, for each of the analog power supplies, the pins for the left group of GTH Quads are connected to common planes inside the package. As a result, there are four GTH Quad analog power supply planes on each side of the package. On each side of the FPGA that has GTH Quads, there is an MGTHAVCC, MGTHAVCCRX, MGTHAVCCPLL, and MGTHAVTT power plane inside the package.

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As shown Table 5-2, there are two groupings of the GTH_QUADs columns.

- Devices with two columns of GTH_QUADs
  - Left column of GTH_QUADs
  - Right column of GTH_QUADs
- Devices with one column of GTH_QUADs on the right-side column

Table 5-2: **Virtex-6 FPGAs GT Transceivers Grouped by Devices, Packages, and Power Planes**

Device/ Package	GTX Transceivers							GTH Transceivers		
	Left Side	MGT100	MGT101	MGT102	MGT103	MGT104	MGT105	MGT106	MGT107	MGT108
	Right Side	MGT110	MGT111	MGT112	MGT113	MGT114	MGT115	MGT116	MGT117	MGT118
HX250T-FF1154	Left Side	South_L	South_L	South_L	North_L	North_L	North_L			
	Right side	South_R	South_R	South_R	North_R	North_R	North_R			
HX255T-FF1155	Left Side				North_L	North_L	North_L			
	Right side				North_R	North_R	North_R	Common_R	Common_R	Common_R
HX255T-FF1923	Left Side				North_L	North_L	North_L	Common_L	Common_L	Common_L
	Right side				North_R	North_R	North_R	Common_R	Common_R	Common_R
HX380T-FF1154	Left Side	South_L	South_L	South_L	North_L	North_L	North_L			
	Right side	South_R	South_R	South_R	North_R	North_R	North_R			
HX380T-FF1155	Left Side				North_L	North_L	North_L			
	Right side				North_R	North_R	North_R	Common_R	Common_R	Common_R
HX380T-FF1923	Left Side	South_L	South_L	South_L	North_L	North_L	North_L	Common_L	Common_L	Common_L
	Right side			North_R	North_R	North_R	North_R	Common_R	Common_R	Common_R
HX380T-FF1924	Left Side	South_L	South_L	South_L	North_L	North_L	North_L	Common_L	Common_L	Common_L
	Right side	South_R	South_R	South_R	North_R	North_R	North_R	Common_R	Common_R	Common_R
HX565T-FF1923	Left Side	South_L	South_L	South_L	North_L	North_L	North_L	Common_L	Common_L	Common_L
	Right side			North_R	North_R	North_R	North_R	Common_R	Common_R	Common_R
HX565T-FF1924	Left Side	South_L	South_L	South_L	North_L	North_L	North_L	Common_L	Common_L	Common_L
	Right side	South_L	South_L	South_L	North_R	North_R	North_R	Common_R	Common_R	Common_R

Notes:

1. Right and left are oriented to the bottom view of the package.
2. South_L: South bank GTX power planes on left side of the package.
3. North_L: North bank GTX power planes on the left side of the package.
4. South_R: South bank GTX power planes on the right side of the package.
5. North_R: North bank GTX power planes on the right side of the package.
6. Common_L: GTH power planes on the left side of the package.
7. Common_R: GTH power planes on the right side of the package.

Figure 5-2 shows the orientation in the device of the GTH_QUAD power groups within a device. The type of grouping for the GTH_QUADs in a column depends on the device package. The FF484 and FF784 packages have a single common power plane for each of the MGT supplies. The FF1156 and FF1759 packages have two power planes for each of the MGT power supplies.

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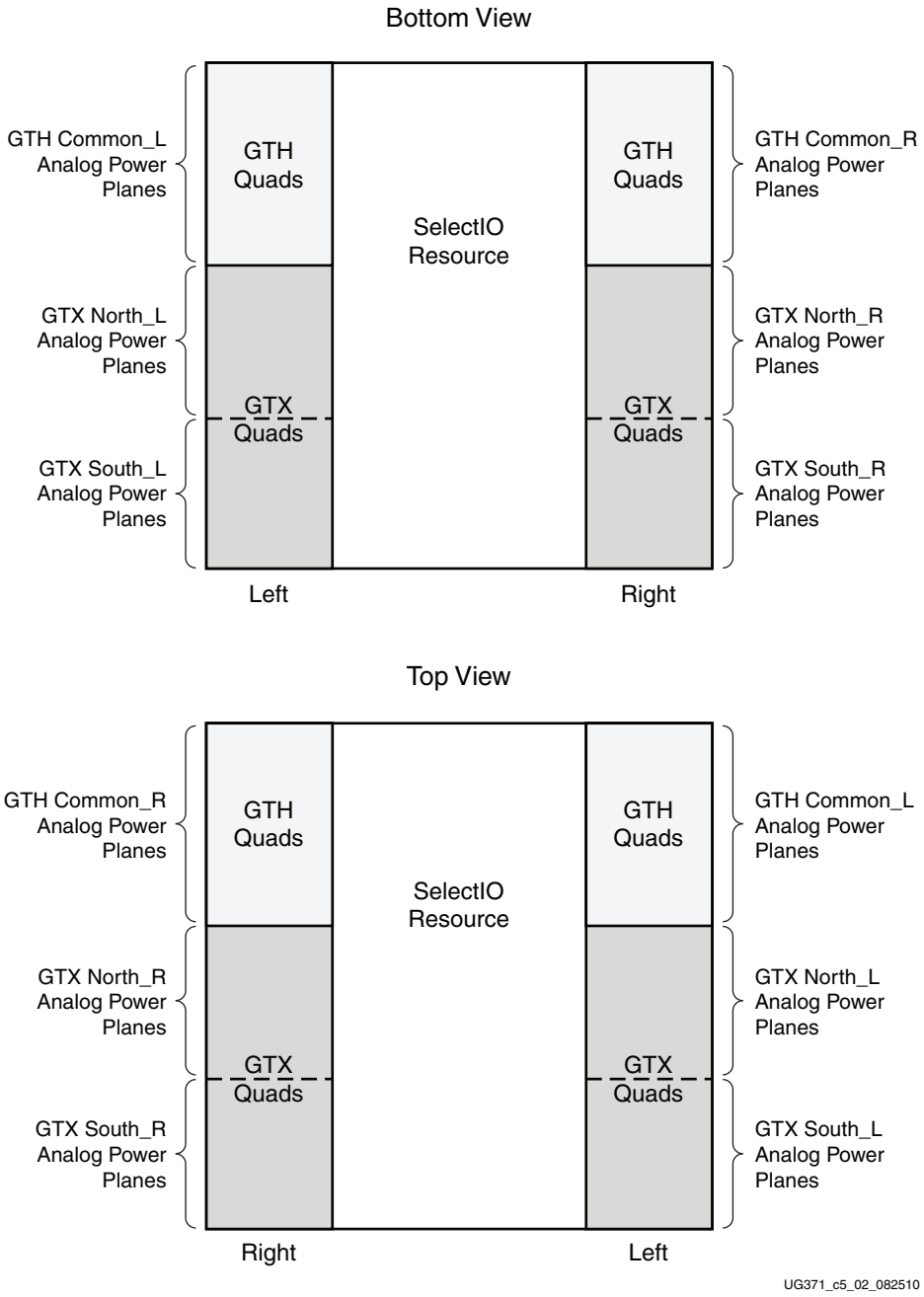

Figure 5-2: **GTH and GTX Power Plane Group Orientation in Virtex-6 FPGA Packages**

Unused GTH_QUAD Column

When none of the GTH_QUADs on a side of the device are used in the application, the GTH_QUAD device pins can be connected as shown in Table 5-3.

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Table 5-3: **Unused GTH_QUAD Column Connections**

Pin Name	Unused Connections
MGTRXP[0:3] MGTRXN[0:3]	V_{CCINT} (1.0V)
MGTTXP[0:3] MGTTXN[0:3]	V_{CCINT} (1.0V)
MGTREFCLKP MGTREFCLKN	V_{CCINT} (1.0V)
MGTHAVCC	V_{CCINT} (1.0V)
MGTHAVCCRX	V_{CCINT} (1.0V)
MGTHAVCCPLL	V_{CCINT} (1.0V)
MGTHAVTT	V_{CCINT} (1.0V)
MGTRBIAS	V_{CCINT} (1.0V)

Partially Unused GTH_QUAD Column

When only a portion of the GTH_QUADs on a side of the FPGA is used, then the unused GTH Quads on that side of the FPGA must be connected as shown in Table 5-4.

Table 5-4: **Unused GTH_QUAD Pin Connections for a Partially Unused Side**

Pin Name	Unused Connections
MGTRXP[0:3] MGTRXN[0:3]	Float
MGTTXP[0:3] MGTTXN[0:3]	Float
MGTREFCLKP MGTREFCLKN	GND
MGTHAVCC	1.1 V_{DC}, see Table 5-1
MGTHAVCCRX	1.1 V_{DC}, see Table 5-1
MGTHAVCCPLL	1.8 V_{DC}, see Table 5-1
MGTHAVTT	1.2 V_{DC}, see Table 5-1
MGTRBIAS	MGTHAVTT, see Table 5-1

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Partially Used GTH_QUAD

There are four GTH transceivers in a Virtex-6 FPGA GTH_QUAD. In a partially used GTH_QUAD, where one or more but not all of the transceivers are unused, Table 5-5 shows the power supply and RBIAS connections to the GTH_QUAD for the GTH transceivers that are not used. The required connections to the unused transceiver data pins are shown in Table 5-6.

Table 5-5: **Power Supply and RBIAS Pin Connections for a Partially Used GTH_QUAD**

Pin Name	Connection
MGTHAVCC	1.1 V_{DC}, see Table 5-1
MGTHAVCCRX	1.1 V_{DC}, see Table 5-1
MGTHAVCCPLL	1.8 V_{DC}, see Table 5-1
MGTHAVTT	1.2 V_{DC}, see Table 5-1
MGTRBIAS	MGTAVTT, see Table 5-1

Table 5-6: **Unused GTH Transceiver Connections in a Partially Used GTH_QUAD**

Pin Name	Connection	Description
MGTRXP MGTRXN	Float	Unused GTH receiver
MGTTXP MGTTXN	Float	Unused GTH transmitter

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Reference Clock

This section provides an overview of the reference clock requirements, criteria for reference clock oscillator selection, and the reference clock interface.

Overview

This section focuses on selection of the reference clock source or oscillator. An oscillator is characterized by:

- Frequency range
- Output voltage swing
- Jitter (deterministic, random, peak-to-peak)
- Rise and fall times
- Supply voltage and current
- Noise specification
- Duty cycle and duty-cycle tolerance
- Frequency stability

These characteristics are selection criteria when choosing an oscillator for a GTH transceiver design. Figure 5-3 illustrates the convention for the single-ended clock input voltage swing (peak-to-peak), as used in the GTH transceiver portion of DS152, *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*.

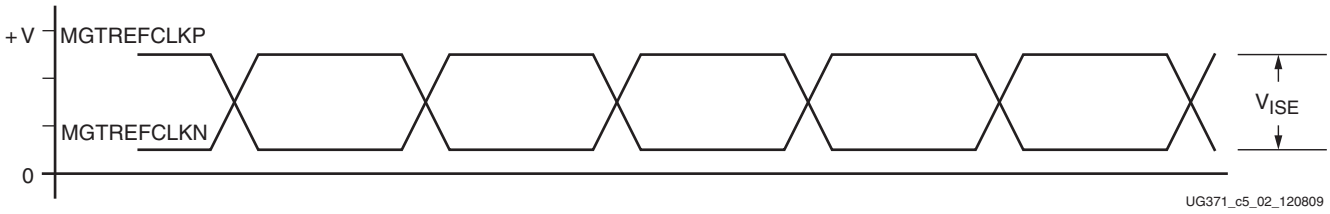

Figure 5-3: **Single-Ended Clock Input Voltage Swing (Peak-to-Peak)**

Figure 5-4 illustrates the differential clock input voltage swing (peak-to-peak), which is defined as MGTREFCLKP – MGTREFCLKN.

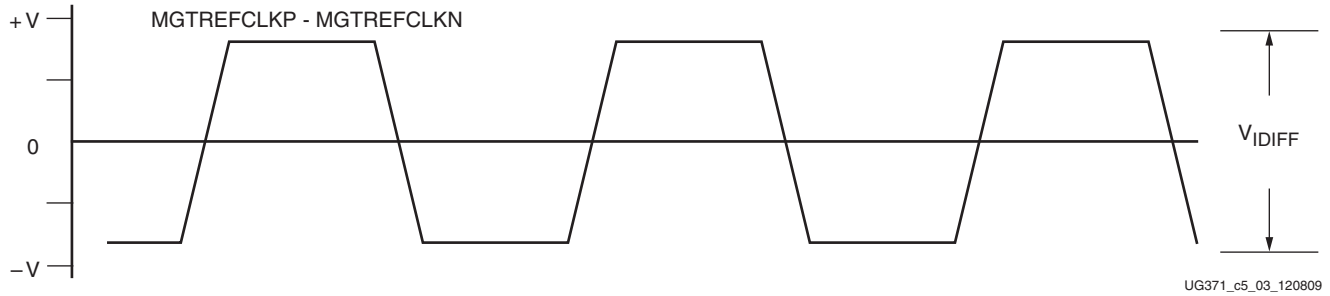

Figure 5-4: **Differential Clock Input Voltage Swing (Peak-to-Peak)**

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Figure 5-5 shows the rise and fall time conventions of the reference clock.

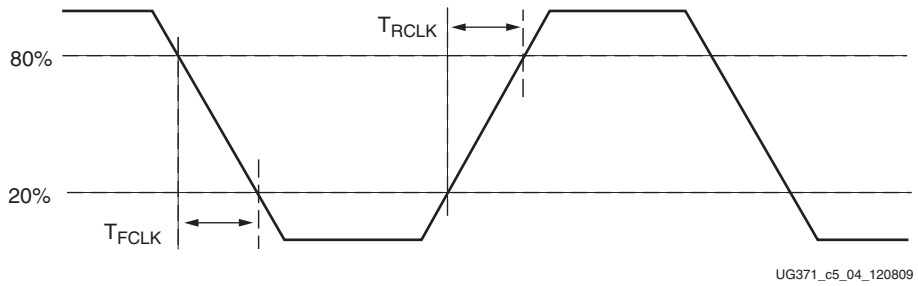

Figure 5-5: **Rise and Fall Times**

GTH Transceiver Reference Clock Checklist

Certain criteria must be met when choosing an oscillator for a design with GTH transceivers:

- AC coupling must be provided between the oscillator output pins and the dedicated GTH Quad clock input pins.
- The differential voltage swing of the reference clock must have the range specified in the *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*. The nominal range is 500 mV–1600 mV and the nominal typical value is 800 mV.
- The reference clock characteristics must meet or exceed those specified in the *Virtex-6 FPGA Data Sheet: DC and Switching Characteristics*.
- The reference clock characteristics must meet or exceed those specified in the standard for which the GTH transceiver provides physical layer support.
- Requirements set by the oscillator vendor regarding power supply, board layout, and noise specification must be met.
- A dedicated point-to-point connection must be provided between the oscillator and GTH Quad clock input pins.
- Impedance discontinuities on the differential transmission lines must be kept to a minimum because impedance discontinuities generate jitter.

Reference Clock Interface

This section discusses the interface between an external reference clock and the GTH transceiver reference clock input. Specifically the interface to an external reference clock with an LVPECL output including AC coupling, pin connections for unused reference clock inputs, and signal integrity issues related to the reference clock circuit.

LVPECL

A reference clock oscillator with an LVPECL output is recommended. An LVDS output reference clock oscillator is not recommended because the LVDS output does not meet the minimum signal amplitude requirements for the GTH transceiver reference clock input. Figure 5-6 provides an example of how to interface an LVPECL output reference clock oscillator to the GTH transceiver reference clock input.

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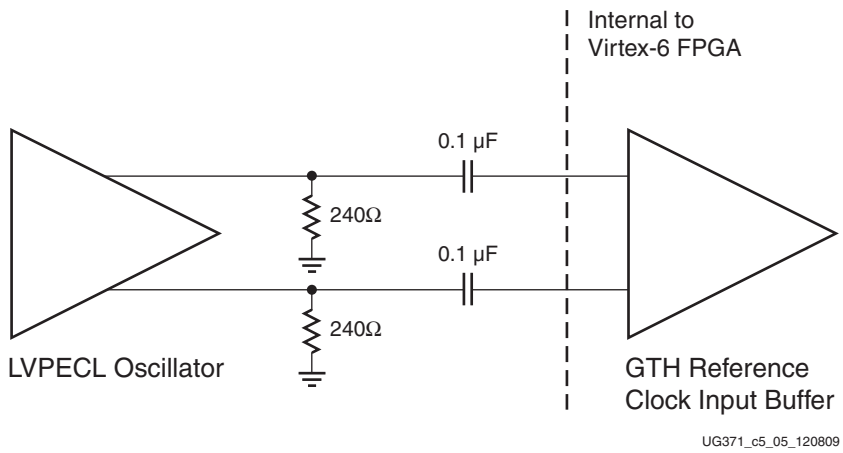

Figure 5-6: **Interfacing an LVPECL Oscillator and GTH Transceiver Reference Clock Input**

In Figure 5-6, the resistor values shown are nominal values. Refer to the oscillator vendor data sheet for the actual bias resistor requirement.

AC Coupled Reference Clock

AC coupling of the oscillator reference clock output to the GTH Quad reference clock inputs serves multiple purposes:

- It blocks DC current between the oscillator and the GTH Quad dedicated clock input pins. This has the added benefit of reducing the power consumption of both parts.
- Common mode voltage independence is achieved.
- The AC coupling capacitor forms a high-pass filter with the on-chip termination that attenuates reference clock wander.

To minimize noise and power consumption, external AC coupling capacitors between the sourcing oscillator and the GTH Quad dedicated clock reference clock input pins are required.

Unused Reference Clocks

It is recommended to connect the unused differential input pin clock pair (both MGTREFCLKP and MGTREFCLKN) to ground or leave them floating.

Reference Clock Power

The GTH transceiver reference clock input circuit is powered by MGTHAVCCPLL and MGTHAVCCRX. Excessive noise on these supplies has a negative impact on the performance of any GTH Quad that uses the reference clock from this circuit.

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Power Supplies and Filtering

This section discusses the GTH transceiver power supplies, the two main types of power supply regulators (linear and switching), and performance degradation due to crosstalk.

Overview

The Virtex-6 FPGA GTH Quad requires four analog power supplies:

- MGTHAVCC, at a nominal voltage level of 1.1 V_{DC}
- MGTHAVCCRX, at a nominal voltage level of 1.1 V_{DC}
- MGTHAVTT, at a nominal voltage level of 1.2 V_{DC}
- MGTHAVCCPLL, at a nominal voltage of 1.8 V_{DC}

Noise on the GTH transceiver analog power supplies can cause degradation in the performance of the transceivers. The most likely form of degradation is an increase in jitter at the output of the GTH transmitter and reduced jitter tolerance in the receiver. Sources of power supply noise are:

- Power supply regulator noise
- The power distribution network
- Coupling from other circuits

Each noise source must be considered in the design and implementation of the GTH transceiver analog power supplies. The total peak-to-peak noise as measured at the input pin of the FPGA should not exceed 10 mV_{PK-PK}.

Power Supply Regulators

Normally, the GTH transceiver analog voltage supplies have local power supply regulators that provide a final stage of voltage regulation. Preferably these regulators are placed as close as is feasible to the GTH transceiver power supply pins. Minimizing the distance between the analog voltage regulators and the GTH transceiver power supply pins reduces the opportunity for noise coupling into the supply after the regulator. It also reduces the opportunity for noise generated by current transients caused by load dynamics.

Linear vs. Switching Regulators

The type of power supply regulator used can have a significant impact on the complexity, cost, and performance of the power supply circuit. A power supply regulator must provide adequate power to the GTH transceiver with a minimum amount of noise while meeting the overall system thermal and efficiency requirements. There are two major types of power supply voltage regulators available for regulating the GTH transceiver analog voltage rails: linear regulators and switching regulators. Both have advantages and disadvantages. The optimal choice of regulator type depends on system requirements such as:

- Physical size
- Thermal budget
- Power efficiency
- Cost

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Linear Regulator

A linear regulator is usually the simplest means to provide voltage regulation for the GTH transceiver analog supply rails. Inherently, a linear regulator does not inject significant noise into the regulated output voltage. In fact some, but not all, linear regulators provide noise rejection at the output from noise present on the voltage input. Another advantage of the linear regulator is that it usually requires a minimal number of external components to realize a circuit on the PCB.

There are potentially two major disadvantages to linear regulators: the minimum dropout voltage and limited efficiency. Linear regulators require an input voltage that is higher than the output voltage. This minimum dropout voltage often is dependent on the load current. Even low dropout linear regulators require a minimum difference between the input voltage and the output voltage of the regulator. The system power supply design must meet the minimum dropout voltage requirements of the linear regulators.

The efficiency of a linear regulator is dependent on the voltage difference between the input and output of the linear regulator. For instance, if the input voltage of the regulator is 2.5 V_{DC}, and the output voltage of the regulator is 1.2 V_{DC}, the voltage difference is 1.3 V_{DC}. Assuming that the current into the regulator is essentially equal to the current out of the regulator, the maximum efficiency of the regulator is 48%. For every watt delivered to the load, the system must consume an additional watt for regulation. This power consumed by the regulator generates heat that must be dissipated by the system. Providing a means to dissipate the heat generated by the linear regulator can drive up the system cost. Therefore, even though linear regulators are less complex and use fewer external components, if the overall system cost is considered (including power consumption and heat dissipation), linear regulators can be at a disadvantage in high current applications.

Switching Regulator

A switching regulator can provide a very efficient means to deliver a well regulated voltage for the GTH transceiver analog power supply. Unlike the linear regulator, the switching regulator does not depend on the voltage drop between the input voltage of the regulator and the output voltage to provide regulation. Therefore, the switching regulator can supply large amounts of current to the load while maintaining high power efficiency. It is not uncommon for a switching regulator to maintain efficiencies of 95% or greater. This efficiency is not severely impacted by the voltage drop between the input of the regulator and the output. Additionally, it is impacted by the load current to a much lesser degree than the linear regulator. Because of the efficiency of the switching regulator, the system does not need to supply as much power to the circuit, and it does not need to provide a means to dissipate power consumed by the regulator.

The disadvantages of the switching regulator are the complexity of the circuit and noise generated by the regulator switching function. Switching regulator circuits are usually more complex than linear regulator circuits. This shortcoming has recently been addressed by several switching regulator component vendors. Normally, a switching power supply regulation circuit requires a switching transistor element, an inductor, and a capacitor. Depending on the required efficiency and load requirements, a switching regulator circuit might require external switching transistors and inductors. In addition, these switching regulators require very careful placement and routing on the PCB to be effective.

Switching regulators generate significant noise and therefore usually require additional filtering before the voltage is delivered to the GTH transceiver analog power supply input of the Virtex-6 FPGA. As mentioned in Overview, page 141, the amplitude of the noise should be limited to less than 10 mV_{PK-PK}. Therefore, the power supply filter should be designed to attenuate the noise from the switching regulator to meet this requirement.

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Voltage Regulators with Remote Voltage Sensing

The area of the printed circuit board that surrounds the GTH transceiver pins has a number of component placement and routing requirements that make it difficult to place the GTH transceiver analog power-supply voltage regulators in close proximity to the GTH transceiver power-supply pins. As the placement of the power-supply regulators is moved further away from the GTH transceiver power-supply pins, the voltage drop due to current flow in the power distribution network becomes more significant.

By using voltage regulators with a remote voltage sense capability, the voltage regulators can be placed at a greater distance from the FPGA. As illustrated in Figure 5-7, the remote voltage sense circuit allows the voltage regulator circuit to compensate for losses in the power distribution network path between the voltage regulator and the GTH transceiver power supply pins.

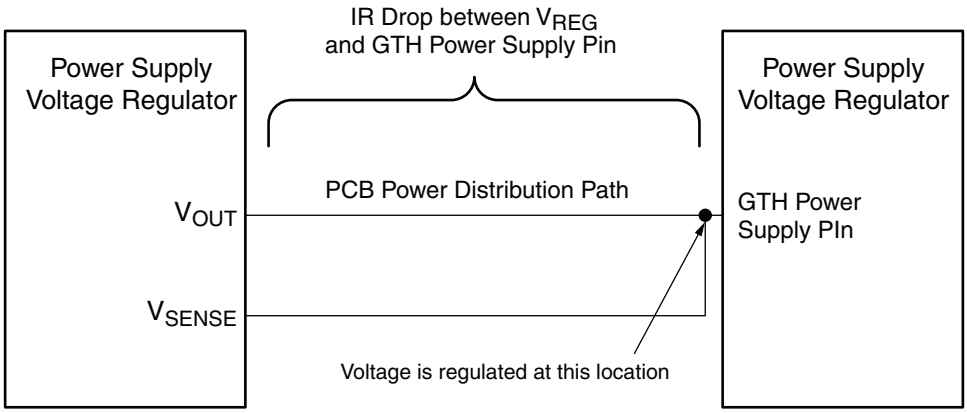

Figure 5-7: **Power Supply Voltage Regulation with Remote Sense**

Power Supply Distribution Network

Staged Decoupling

Die

There is decoupling capacitance on the die to filter the highest frequency noise components on the power supplies. The internal on-die circuits are the source for this very high-frequency noise.

Package

There is additional decoupling in the Virtex-6 FPGA packages. Decoupling capacitors in the package provide attenuation for noise in the package power plane, thereby reducing the interaction between the GTH Quads. These capacitors in the package also help to maintain a path that is low impedance at high frequencies between the analog power supplies and ground.

Printed Circuit Board

Because the impedance between the power planes and ground has been kept low on the die and in the package, the requirement for decoupling on the PCB is more relaxed. Also,

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since the power supplies of the GTH Quads are common and decoupled in the package, filtering is not necessary on the PCB to isolate the Quad power supply connections. Decoupling capacitors provide two basic functions:

- Help to isolate one circuit from another so that noise induced on the power supply by one circuit does not induce noise on the power supply of another circuit. In this case, the concern is noise coupling between GTH Quads in the same FPGA.
- Provide isolation between the power supply source and the load circuit.

Power Supply Decoupling Capacitors

For the GTH transceiver analog power supplies, the primary purpose of decoupling capacitors is to reduce the noise amplitude from the power supply source and other circuits on the PCB. Another function of the decoupling capacitors is to minimize the power supply impedance as seen by the transceiver circuitry. Table 5-7 lists the power supply requirements. The suggested decoupling for the GTH power supply rails is shown in Table 5-8.

Table 5-7: **Decoupling Capacitors for Each GTH_QUAD Power Supply**

Analog Power Supply	Type	Size	Capacitor Value (µF)	Quantity Per GTH_QUAD Column
MGTHAVCC	Ceramic	0402	0.22	10
	Ceramic	1206	10	1
MGTHAVCCRX	Ceramic	0402	0.22	8
	Ceramic	1206	10	1
MGTHAVCCPLL	Ceramic	0402	0.22	3
	Ceramic	1206	10	1
MGTHAVTT	Ceramic	0402	0.22	4
	Ceramic	1206	10	1

Table 5-8: **Suggested Decoupling Capacitors**

Capacitor Value	Type	Size	Manufacturer	P/N
0.22 µF	Ceramic	0402	AVX	04026D224KAT2A
			Kemet	C0402C224K9PAC
			Murata	GRM155R60J224KE01
10 µF	Ceramic	1206	AVX	1206YD106KAT2A
			Kemet	C1206C106K4PAC
			Murata	GRM31CR61C106KA88

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MGTHAVCC Decoupling Capacitor Layout

Minimizing the inductance in the path from the MGTHAVCC power supply pins and the decoupling capacitors is critical. A method for placement and layout for connecting these capacitors to the MGTHAVCC pin vias on the non-component side of the PCB is shown in Figure 5-8. For this example, the layout depends on the use of blind vias for routing the GTH RX/TX data signals. The use of blind vias will result in gaps in the via pin field on the non-component side of the board.

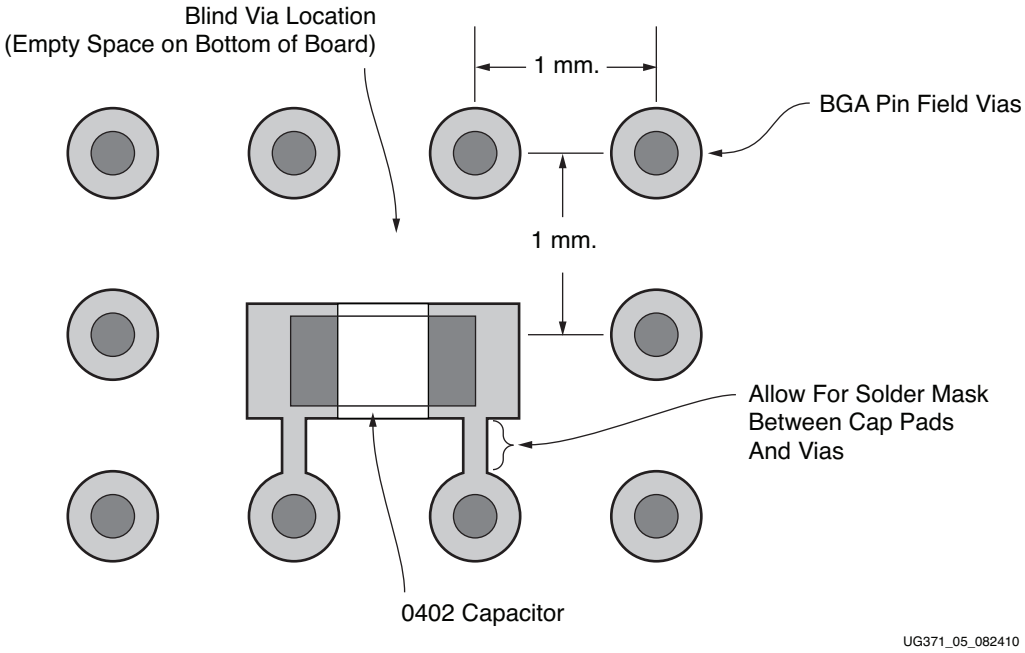

Figure 5-8: **Placing MGTHAVCC Decoupling Capacitors**

An alternative method for placing the MGTHAVCC de-coupling capacitors is to use filled via-in-pads. An example for placement and layout of the de-coupling capacitors is shown in Figure 5-9.

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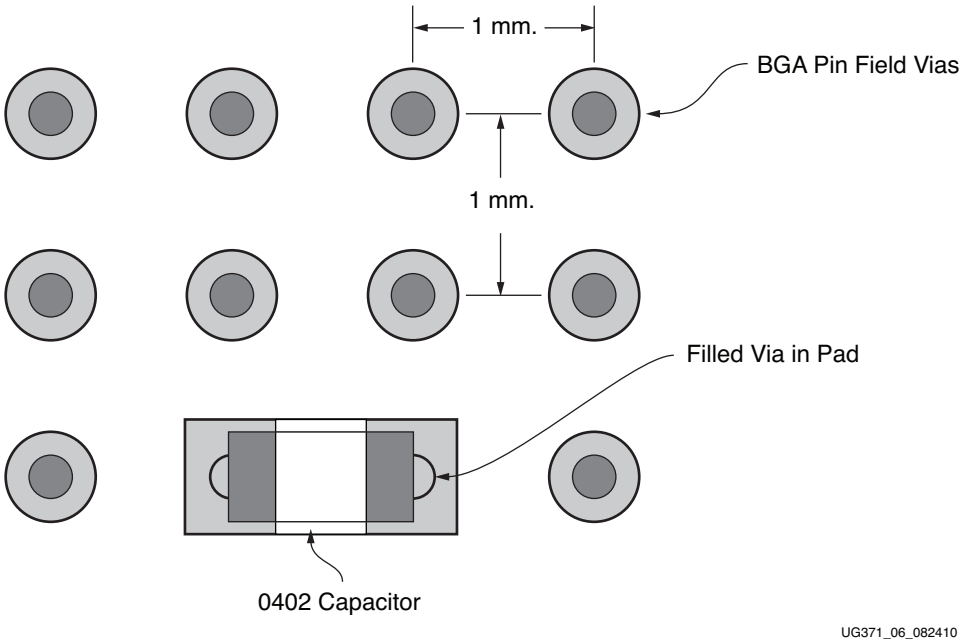

Figure 5-9: **Placing MGTHAVCC Decoupling Capacitors Using Filled Via-in-Pad**

Printed Circuit Board Design

Optimal performance from the GTH transceivers requires careful consideration in the design of the PCB. The areas of PCB design that must be considered are board stackup, component placement, and signal routing. The PCB design includes:

- Power distribution network for MGTHAVCC, MGTHAVCCRX, MGTHAVCCPLL, and MGTHAVTT
- Data lines for the receiver and transmitter
- Reference clock connections between the source oscillator and the GTH reference clock input
- Termination calibration resistor (see Termination Resistor Calibration Circuit)

This subsection discusses the implementation of these designs on the PCB.

GTH Transceiver Power Connections

Connections between the GTH power pins and the power distribution network are critical to the overall transceiver performance. The interface between the power distribution network and FPGA must be low impedance and low noise. The maximum noise allowed on the GTH power supplies at the FPGA is 10 mV_{PP} from 10 kHz to 80 MHz.

Signal BGA Breakout

The receiver, transmitter, and reference clock signals must be routed from the BGA pin field to destinations on the PCB. The signal routing layers provide the routing resources for this signal breakout. As shown in Figure 5-10, the signals on the outer rows of BGA pins can be routed using a microstrip on the top layer. These signals are routed to vias where the signal is transitioned from the top microstrip layer to striplines on layer 3. An advantage to

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routing the signals from layer 1 to layer 3 is that the traces on both layers use the plane on layer 2 as the return current reference plane.

For signals that are on the inner rows of pins, it is necessary to route from the BGA pin pad on top of the board to a via. The signal pair is routed from each via by striplines on layers 5 and 7 as shown in Figure 5-11. The Virtex-6 FPGA packages are designed with grounds adjacent to all of the GTH transceiver signal pins. Having adjacent ground pins leads to adjacent BGA breakout vias. The adjacent ground vias provide a return current path for the signal via as the signal propagates from one layer to another layer in the stackup. If the two layers that are connected to the signal via have separate ground planes, the adjacent ground via provides a return current path in the Z-axis and thereby reduces the inductance of the via.

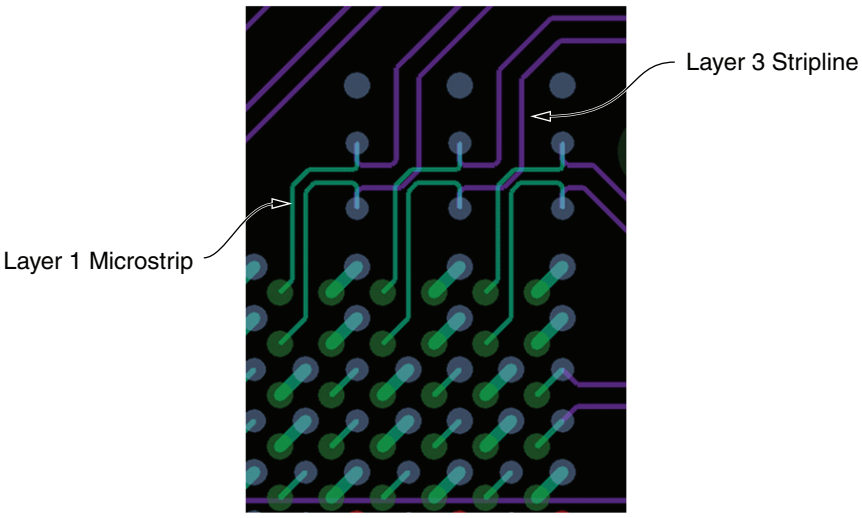

Figure 5-10: **TX Microstrip Breakout**

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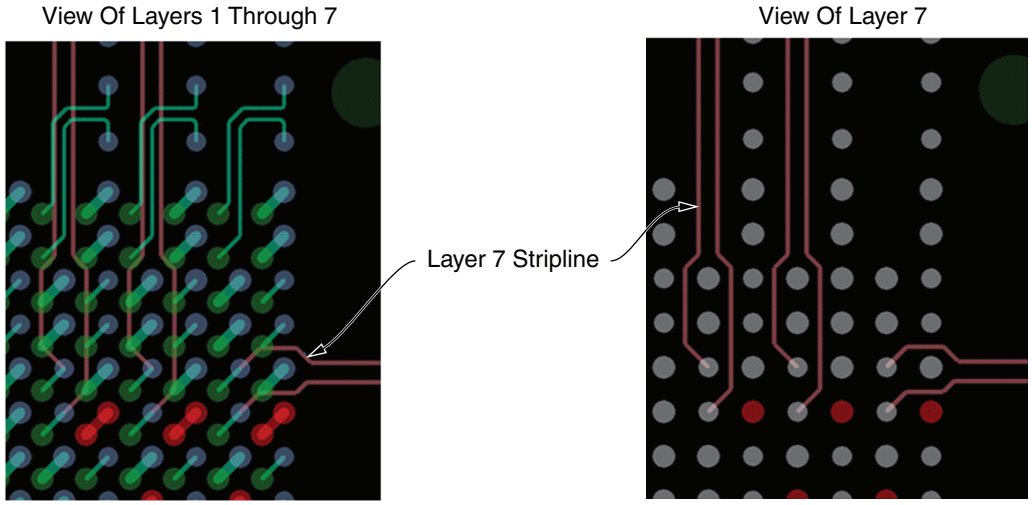

- For GTH TX/RX pins that are not on the outer edge of the FPGA package
- Use stripline from dog-bone via to breakout from BGA pin pad
- Since outer pin signals do not have vias, the resulting via gap provides routing paths for inner BGA pin breakout

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Figure 5-11: **RX BGA Breakout to Stripline**

Crosstalk

A major contributor to degradation in the performance of a GTH transceiver is crosstalk. The mechanisms for crosstalk are aggressor signals coupling into signal traces, coupling into the GTH transceiver power supplies, or a combination of both. The latter is the most common and often the most damaging. Noise coupled into the power supply can corrupt the entire transceiver circuit rather than just a single lane—as in the case of coupling into signal traces. Also, symptoms of noise coupled into the power supply are often more difficult to interpret because the noise is convolved with the normal signals in the transceiver. The result is degradation in the performance of the transceiver that reveals itself as noise in the transmitter output and reduced jitter tolerance in the receiver.

To avoid performance degradation from crosstalk:

- Exposure of power planes to other circuits on the board, such as data lines for memory interfaces and processor buses, should be monitored.
- Adequate filtering should be provided to the GTH transceiver power supplies near the point of the load. The amount of filtering should be determined by the magnitude and frequency of the signal from potential noise sources. Noise on the GTH transceiver power supplies should be kept below 10 mV_{PK-PK} from 10 KHz to 80 MHz.
- Return current paths of signal traces in the vicinity of the GTH transceiver power distribution network should be monitored. Besides broadband and edge coupling of traces on the same or adjacent layers, coupling from aggressor traces can occur if the aggressor signal is propagating from one layer to another, each layer having a different reference plane. As the signal propagates through the portion of the via that does not have a return current path, it generates return currents in the next lowest impedance structure on the board. A victim of this unintended return current path could be a signal or power via for the GTH transceivers.

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SelectIO Interface Usage Guidelines

Because the GTH transceiver's performance can degrade in an environment flooded with SelectIO™ interface activity, it is important to have guidelines for SelectIO interface usage that minimize the impact on GTH transceiver performance.

The pinout for the Virtex-6 FPGA package maintains a physical separation between the GTH transceiver pins and the SelectIO interface pins. Because of this separation in the package pinout, no SelectIO interface pins need to be excluded when using the GTH transceivers.

Even though the Virtex-6 FPGA package pinout eliminates the crosstalk between the SelectIO interface and the GTH transceiver pins due to pin adjacency, it is still possible to induce crosstalk on the PCB. Therefore, when routing signals on the PCB:

- Routing of GTH transceiver signals and SelectIO interface signals on adjacent layers should be eliminated. If these signals are routed on adjacent layers there is potential for broadside coupling.
- Isolation of the return current paths should be maintained for both the SelectIO interface signals and the GTH transceiver signals, including both traces and vias.
- SelectIO interface signals should not be routed over or through the GTH transceiver power islands. The power islands for the GTH transceivers are also a potential source for SelectIO interface induced noise.

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Appendix A

DRP Address Map of GTH Transceivers

DRP Address Map of the GTH Transceivers

Table A-1 and Table A-2 list the DRP map sorted by attribute names.

Table A-1: **GTH_QUAD Attributes**

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
BER_CONST_PTRN0	16-bit Hex	0x0053	0x7000	0xC000 – 0x03
BER_CONST_PTRN1	16-bit Hex	0x0054	0x7001	0xC001 – 0x03
BUFFER_CONFIG_LANE0	16-bit Hex	0x004F	N/A	N/A
BUFFER_CONFIG_LANE1		0x0052		
BUFFER_CONFIG_LANE2		0x00F0		
BUFFER_CONFIG_LANE3		0x00ED		
DFE_TRAIN_CTRL_LANE0	16-bit Hex	0x003A	0x4015	0x8015 – 0x01
DFE_TRAIN_CTRL_LANE1		0x008A	0x4115	
DFE_TRAIN_CTRL_LANE2		0x00C2	0x4215	
DFE_TRAIN_CTRL_LANE3		0x0105	0x4315	
DLL_CFG0	16-bit Hex	0x0011	0x6002	0xC002 – 0x01
DLL_CFG1	16-bit Hex	0x0022	0x601D	0xC01D – 0x01
E10GBASEKR_LD_COEFF_UPD_LANE0	16-bit Hex	0x000D	0x209A	0x009A – 0x01
E10GBASEKR_LD_COEFF_UPD_LANE1		0x0073	0x219A	
E10GBASEKR_LD_COEFF_UPD_LANE2		0x00AB	0x229A	
E10GBASEKR_LD_COEFF_UPD_LANE3		0x00E7	0x239A	
E10GBASEKR_LP_COEFF_UPD_LANE0	16-bit Hex	0x000C	0x2098	0x0098 – 0x01
E10GBASEKR_LP_COEFF_UPD_LANE1		0x0072	0x2198	
E10GBASEKR_LP_COEFF_UPD_LANE2		0x00AA	0x2298	
E10GBASEKR_LP_COEFF_UPD_LANE3		0x00E6	0x2398	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
E10GBASEKR_PMA_CTRL_LANE0	16-bit Hex	0x000B	0x2096	0x0096 – 0x01
E10GBASEKR_PMA_CTRL_LANE1		0x0071	0x2196	
E10GBASEKR_PMA_CTRL_LANE2		0x00A9	0x2296	
E10GBASEKR_PMA_CTRL_LANE3		0x00E5	0x2396	
E10GBASEKX_CTRL_LANE0	16-bit Hex	0x000E	0x20A0	0x00A0 – 0x01
E10GBASEKX_CTRL_LANE1		0x0074	0x21A0	
E10GBASEKX_CTRL_LANE2		0x00AC	0x22A0	
E10GBASEKX_CTRL_LANE3		0x00E8	0x23A0	
E10GBASER_PCS_CFG_LANE0	16-bit Hex	0x0062	0x5080	0x8080 – 0x03
E10GBASER_PCS_CFG_LANE1		0x00A5	0x5180	
E10GBASER_PCS_CFG_LANE2		0x00DD	0x5280	
E10GBASER_PCS_CFG_LANE3		0x120	0x5380	
E10GBASER_PCS_SEEDA0_LANE0	16-bit Hex	0x0043	0x3022	0x0022 – 0x03
E10GBASER_PCS_SEEDA0_LANE1		0x0093	0x3122	
E10GBASER_PCS_SEEDA0_LANE2		0x00CB	0x3222	
E10GBASER_PCS_SEEDA0_LANE3		0x010E	0x3322	
E10GBASER_PCS_SEEDA1_LANE0	16-bit Hex	0x0044	0x3023	0x0023 – 0x03
E10GBASER_PCS_SEEDA1_LANE1		0x0094	0x3123	
E10GBASER_PCS_SEEDA1_LANE2		0x00CC	0x3223	
E10GBASER_PCS_SEEDA1_LANE3		0x010F	0x3323	
E10GBASER_PCS_SEEDA2_LANE0	16-bit Hex	0x0045	0x3024	0x0024 – 0x03
E10GBASER_PCS_SEEDA2_LANE1		0x0095	0x3124	
E10GBASER_PCS_SEEDA2_LANE2		0x00CD	0x3224	
E10GBASER_PCS_SEEDA2_LANE3		0x0110	0x3324	
E10GBASER_PCS_SEEDA3_LANE0	16-bit Hex	0x0046	0x3025	0x0025 – 0x03
E10GBASER_PCS_SEEDA3_LANE1		0x0096	0x3125	
E10GBASER_PCS_SEEDA3_LANE2		0x00CE	0x3225	
E10GBASER_PCS_SEEDA3_LANE3		0x0111	0x3325	
E10GBASER_PCS_SEEDB0_LANE0	16-bit Hex	0x0047	0x3026	0x0026 – 0x03
E10GBASER_PCS_SEEDB0_LANE1		0x0097	0x3126	
E10GBASER_PCS_SEEDB0_LANE2		0x00CF	0x3226	
E10GBASER_PCS_SEEDB0_LANE3		0x0112	0x3326	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
E10GBASER_PCS_SEEDB1_LANE0	16-bit Hex	0x0048	0x3027	0x0027 – 0x03
E10GBASER_PCS_SEEDB1_LANE1		0x0098	0x3127	
E10GBASER_PCS_SEEDB1_LANE2		0x00D0	0x3227	
E10GBASER_PCS_SEEDB1_LANE3		0x0113	0x3327	
E10GBASER_PCS_SEEDB2_LANE0	16-bit Hex	0x0049	0x3028	0x0028 – 0x03
E10GBASER_PCS_SEEDB2_LANE1		0x0099	0x3128	
E10GBASER_PCS_SEEDB2_LANE2		0x00D1	0x3228	
E10GBASER_PCS_SEEDB2_LANE3		0x0114	0x3328	
E10GBASER_PCS_SEEDB3_LANE0	16-bit Hex	0x004A	0x3029	0x0029 – 0x03
E10GBASER_PCS_SEEDB3_LANE1		0x009A	0x3129	
E10GBASER_PCS_SEEDB3_LANE2		0x00D2	0x3229	
E10GBASER_PCS_SEEDB3_LANE3		0x0115	0x3329	
E10GBASER_PCS_TEST_CTRL_LANE0	16-bit Hex	0x004B	0x302A	0x002A – 0x03
E10GBASER_PCS_TEST_CTRL_LANE1		0x009B	0x312A	
E10GBASER_PCS_TEST_CTRL_LANE2		0x00D3	0x322A	
E10GBASER_PCS_TEST_CTRL_LANE3		0x0116	0x332A	
E10GBASEX_PCS_TSTCTRL_LANE0	16-bit Hex	0x0042	0x3019	0x0019 – 0x03
E10GBASEX_PCS_TSTCTRL_LANE1		0x0092	0x3119	
E10GBASEX_PCS_TSTCTRL_LANE2		0x00CA	0x3219	
E10GBASEX_PCS_TSTCTRL_LANE3		0x010D	0x3319	
GLBL0_NOISE_CTRL	16-bit Hex	0x0018	0x600C	0xC00C- 0x01
GLBL_AMON_SEL	16-bit Hex	0x0014	0x6006	0xC006 – 0x01
GLBL_DMON_SEL	16-bit Hex	0x0016	0x6008	0xC008 – 0x01
GTH_CFG_PWRUP_LANE0	1-bit Binary	0x004E[1]	N/A	N/A
GTH_CFG_PWRUP_LANE1		0x0051[1]	N/A	N/A
GTH_CFG_PWRUP_LANE2		0x00F1[1]	N/A	N/A
GTH_CFG_PWRUP_LANE3		0x00EE[1]	N/A	N/A
GLBL_PWR_CTRL	16-bit Hex	0x0020	0x601A	0xC01A – 0x01
LANE_AMON_SEL	16-bit Hex	0x0015	0x6007	0xC007 – 0x01
LANE_DMON_SEL	16-bit Hex	0x0017	0x6009	0xC009 – 0x01
LANE_LNK_CFGOVRD	16-bit Hex	0x0055	0x7003	0xC003 – 0x03

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
LANE_PWR_CTRL_LANE0	16-bit Hex	0x003B	0x4016	0x8016 – 0x01
LANE_PWR_CTRL_LANE1		0x008B	0x4116	
LANE_PWR_CTRL_LANE2		0x00C3	0x4216	
LANE_PWR_CTRL_LANE3		0x0106	0x4316	
LNK_TRN_CFG_LANE0	16-bit Hex	0x003E	0x4030	0x8030 – 0x01
LNK_TRN_CFG_LANE1		0x008E	0x4130	
LNK_TRN_CFG_LANE2		0x00C6	0x4230	
LNK_TRN_CFG_LANE3		0x0109	0x4330	
LNK_TRN_COEFF_REQ_LANE0	16-bit Hex	0x003F	0x4031	0x8031 – 0x01
LNK_TRN_COEFF_REQ_LANE1		0x008F	0x4131	
LNK_TRN_COEFF_REQ_LANE2		0x00C7	0x4231	
LNK_TRN_COEFF_REQ_LANE3		0x010A	0x4331	
MISC_CFG	16-bit Hex	0x0012	0x6003	0xC003 – 0x01
MODE_CFG1	16-bit Hex	0x0067	N/A	N/A
MODE_CFG2	16-bit Hex	0x0068	N/A	N/A
MODE_CFG3	16-bit Hex	0x0069	N/A	N/A
MODE_CFG4	16-bit Hex	0x006A	N/A	N/A
MODE_CFG5	16-bit Hex	0x006B	N/A	N/A
MODE_CFG6	16-bit Hex	0x006C	N/A	N/A
MODE_CFG7	16-bit Hex	0x006D	N/A	N/A
PCS_ABILITY_LANE0	16-bit Hex	0x0060	0x5040	0x8040 – 0x03
PCS_ABILITY_LANE1		0x00A3	0x5140	
PCS_ABILITY_LANE2		0x00DB	0x5240	
PCS_ABILITY_LANE3		0x011E	0x5340	
PCS_CTRL1_LANE0	16-bit Hex	0x0040	0x3000	0x0000 – 0x03
PCS_CTRL1_LANE1		0x0090	0x3100	
PCS_CTRL1_LANE2		0x00C8	0x3200	
PCS_CTRL1_LANE3		0x010B	0x3300	
PCS_CTRL2_LANE0	16-bit Hex	0x0041	0x3007	0x0007 – 0x03
PCS_CTRL2_LANE1		0x0091	0x3107	
PCS_CTRL2_LANE2		0x00C9	0x3207	
PCS_CTRL2_LANE3		0x010C	0x3307	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
PCS_MISC_CFG_0_LANE0	16-bit Hex	0x0059	0x5001	0x8001 – 0x03
PCS_MISC_CFG_0_LANE1		0x009C	0x5101	
PCS_MISC_CFG_0_LANE2		0x00D4	0x5201	
PCS_MISC_CFG_0_LANE3		0x0117	0x5301	
PCS_MISC_CFG_1_LANE0	16-bit Hex	0x005E	0x500D	0x800D – 0x03
PCS_MISC_CFG_1_LANE1		0x00A1	0x510D	
PCS_MISC_CFG_1_LANE2		0x00D9	0x520D	
PCS_MISC_CFG_1_LANE3		0x011C	0x530D	
PCS_MODE_LANE0	16-bit Hex	0x004C	0x5000	0x8000 – 0x03
PCS_MODE_LANE1		0x0050	0x5100	
PCS_MODE_LANE2		0x00F3	0x5200	
PCS_MODE_LANE3		0x00EF	0x5300	
PCS_RESET_LANE0	16-bit Hex	0x005C	0x5009	0x8009 – 0x03
PCS_RESET_LANE1		0x009F	0x5109	
PCS_RESET_LANE2		0x00D7	0x5209	
PCS_RESET_LANE3		0x011A	0x5309	
PCS_RESET_1_LANE0	16-bit Hex	0x005F	0x500F	0x800F – 0x03
PCS_RESET_1_LANE1		0x00A2	0x510F	
PCS_RESET_1_LANE2		0x00DA	0x520F	
PCS_RESET_1_LANE3		0x011D	0x530F	
PCS_TYPE_LANE0	16-bit Hex	0x0061	0x5041	0x8041 – 0x03
PCS_TYPE_LANE1		0x00A4	0x5141	
PCS_TYPE_LANE2		0x00DC	0x5241	
PCS_TYPE_LANE3		0x011F	0x5341	
PLL_CFG0	16-bit Hex	0x000F	0x6000	0xC000 – 0x01
PLL_CFG1	16-bit Hex	0x0010	0x6001	0xC001 – 0x01
PLL_CFG2	16-bit Hex	0x0019	0x6011	0xC011 – 0x01
PMA_CTRL1_LANE0	16-bit Hex	0x0008	0x2000	0x0000 – 0x01
PMA_CTRL1_LANE1		0x006E	0x2100	
PMA_CTRL1_LANE2		0x00A6	0x2200	
PMA_CTRL1_LANE3		0x00E2	0x2300	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
PMA_CTRL2_LANE0	16-bit Hex	0x0009	0x2007	0x0007 – 0x01
PMA_CTRL2_LANE1		0x006F	0x2107	
PMA_CTRL2_LANE2		0x00A7	0x2207	
PMA_CTRL2_LANE3		0x00E3	0x2307	
PMA_LPBK_CTRL_LANE0	16-bit Hex	0x0039	0x4014	0x8014 – 0x01
PMA_LPBK_CTRL_LANE1		0x0089	0x4114	
PMA_LPBK_CTRL_LANE2		0x00C1	0x4214	
PMA_LPBK_CTRL_LANE3		0x0104	0x4314	
PRBS_BER_CFG0_LANE0	16-bit Hex	0x005A	0x5007	0x8007 – 0x03
PRBS_BER_CFG0_LANE1		0x009D	0x5107	
PRBS_BER_CFG0_LANE2		0x00D5	0x5207	
PRBS_BER_CFG0_LANE3		0x0118	0x5307	
PRBS_BER_CFG1_LANE0	16-bit Hex	0x005B	0x5008	0x8008 – 0x03
PRBS_BER_CFG1_LANE1		0x009E	0x5108	
PRBS_BER_CFG1_LANE2		0x00D6	0x5208	
PRBS_BER_CFG1_LANE3		0x0119	0x5308	
PRBS_CFG_LANE0	16-bit Hex	0x005D	0x500C	0x800C – 0x03
PRBS_CFG_LANE1		0x00A0	0x510C	
PRBS_CFG_LANE2		0x00D8	0x520C	
PRBS_CFG_LANE3		0x011B	0x530C	
PTRN_CFG0_LSB	16-bit Hex	0x0056	0x7005	0xC005 – 0x03
PTRN_CFG0_MSB	16-bit Hex	0x0057	0x7006	0xC006 – 0x03
PTRN_LEN_CFG	16-bit Hex	0x0058	0x7007	0xC007 – 0x03
PWRUP_DLY	16-bit Hex	0x0021	0x601C	0xC01C – 0x01
RX_AEQ_VAL0_LANE0	16-bit Hex	0x002F	0x400A	0x800A – 0x01
RX_AEQ_VAL0_LANE1		0x007F	0x410A	
RX_AEQ_VAL0_LANE2		0x00B7	0x420A	
RX_AEQ_VAL0_LANE3		0x00FA	0x430A	
RX_AEQ_VAL1_LANE0	16-bit Hex	0x0030	0x400B	0x800B – 0x01
RX_AEQ_VAL1_LANE1		0x0080	0x410B	
RX_AEQ_VAL1_LANE2		0x00B8	0x420B	
RX_AEQ_VAL1_LANE3		0x00FB	0x430B	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
RX_AGC_CTRL_LANE0	16-bit Hex	0x0028	0x4003	0x8003 – 0x01
RX_AGC_CTRL_LANE1		0x0078	0x4103	
RX_AGC_CTRL_LANE2		0x00B0	0x4203	
RX_AGC_CTRL_LANE3		0x00EC	0x4303	
RX_CDR_CTRL0_LANE0	16-bit Hex	0x002A	0x4005	0x8005 – 0x01
RX_CDR_CTRL0_LANE1		0x007A	0x4105	
RX_CDR_CTRL0_LANE2		0x00B2	0x4205	
RX_CDR_CTRL0_LANE3		0x00F5	0x4305	
RX_CDR_CTRL1_LANE0	16-bit Hex	0x002B	0x4006	0x8006 – 0x01
RX_CDR_CTRL1_LANE1		0x007B	0x4106	
RX_CDR_CTRL1_LANE2		0x00B3	0x4206	
RX_CDR_CTRL1_LANE3		0x00F6	0x4306	
RX_CDR_CTRL2_LANE0	16-bit Hex	0x002C	0x4007	0x8007 – 0x01
RX_CDR_CTRL2_LANE1		0x007C	0x4107	
RX_CDR_CTRL2_LANE2		0x00B4	0x4207	
RX_CDR_CTRL2_LANE3		0x00F7	0x4307	
RX_CFG0_LANE0	16-bit Hex	0x0025	0x4000	0x8000 – 0x01
RX_CFG0_LANE1		0x0075	0x4100	
RX_CFG0_LANE2		0x00AD	0x4200	
RX_CFG0_LANE3		0x00E9	0x4300	
RX_CFG1_LANE0	16-bit Hex	0x0026	0x4001	0x8001 – 0x01
RX_CFG1_LANE1		0x0076	0x4101	
RX_CFG1_LANE2		0x00AE	0x4201	
RX_CFG1_LANE3		0x00EA	0x4301	
RX_CFG2_LANE0	16-bit Hex	0x0027	0x4002	0x8002 – 0x01
RX_CFG2_LANE1		0x0077	0x4102	
RX_CFG2_LANE2		0x00AF	0x4202	
RX_CFG2_LANE3		0x00EB	0x4302	
RX_CTLE_CTRL_LANE0	16-bit Hex	0x0031	0x400C	0x800C – 0x01
RX_CTLE_CTRL_LANE1		0x0081	0x410C	
RX_CTLE_CTRL_LANE2		0x00B9	0x420C	
RX_CTLE_CTRL_LANE3		0x00FC	0x430C	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
RX_CTRL_OVRD_LANE0	16-bit Hex	0x003D	0x401E	0x801E – 0x01
RX_CTRL_OVRD_LANE1		0x008D	0x411E	
RX_CTRL_OVRD_LANE2		0x00C5	0x420E	
RX_CTRL_OVRD_LANE3		0x0108	0x430E	
RX_FABRIC_WIDTH0	Integer	0x004E[11:9]	N/A	N/A
RX_FABRIC_WIDTH1		0x0051[11:9]		
RX_FABRIC_WIDTH2		0x00F1[11:9]		
RX_FABRIC_WIDTH3		0x00EE[11:9]		
RX_LOOP_CTRL_LANE0	16-bit Hex	0x0029	0x4004	0x8004 – 0x01
RX_LOOP_CTRL_LANE1		0x0079	0x4104	
RX_LOOP_CTRL_LANE2		0x00B1	0x4204	
RX_LOOP_CTRL_LANE3		0x00F4	0x4304	
RX_MVAL0_LANE0	16-bit Hex	0x002D	0x4008	0x8008 – 0x01
RX_MVAL0_LANE1		0x007D	0x4108	
RX_MVAL0_LANE2		0x00B5	0x4208	
RX_MVAL0_LANE3		0x00F8	0x4308	
RX_MVAL1_LANE0	16-bit Hex	0x002E	0x4009	0x8009 – 0x01
RX_MVAL1_LANE1		0x007E	0x4109	
RX_MVAL1_LANE2		0x00B6	0x4209	
RX_MVAL1_LANE3		0x00F9	0x4309	
RX_P0_CTRL	16-bit Hex	0x001A	0x6014	0xC014 – 0x01
RX_P0S_CTRL	16-bit Hex	0x001B	0x6015	0xC015 – 0x01
RX_P1_CTRL	16-bit Hex	0x001C	0x6016	0xC016 – 0x01
RX_P2_CTRL	16-bit Hex	0x001D	0x6017	0xC017 – 0x01
RX_PI_CTRL0	16-bit Hex	0x0023	0x601E	0xC01E – 0x01
RX_PI_CTRL1	16-bit Hex	0x0024	0x601F	0xC01F – 0x01
SLICE_CFG	16-bit Hex	0x0013	0x6004	0xC004 – 0x01
SLICE_NOISE_CTRL_0_LANE01	16-bit Hex	0x0063	0x8040	0xC040 – 0x01
SLICE_NOISE_CTRL_0_LANE23		0x00DE	0x8240	
SLICE_NOISE_CTRL_1_LANE01	16-bit Hex	0x0064	0x8041	0xC041 – 0x01
SLICE_NOISE_CTRL_1_LANE23		0x00DF	0x8241	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
SLICE_NOISE_CTRL_2_LANE01	16-bit Hex	0x0065	0x8042	0xC042 – 0x01
SLICE_NOISE_CTRL_2_LANE23		0x00E0	0x8242	
SLICE_TX_RESET_LANE01	16-bit Hex	0x0066	0x8043	0xC043 – 0x01
SLICE_TX_RESET_LANE23		0x00E1	0x8243	
TERM_CTRL_LANE0	16-bit Hex	0x0038	0x4013	0x8013 – 0x01
TERM_CTRL_LANE1		0x0088	0x4113	
TERM_CTRL_LANE2		0x00C0	0x4213	
TERM_CTRL_LANE3		0x0103	0x4313	
TX_CFG0_LANE0	16-bit Hex	0x0032	0x400D	0x800D – 0x01
TX_CFG0_LANE1		0x0082	0x410D	
TX_CFG0_LANE2		0x00BA	0x420D	
TX_CFG0_LANE3		0x00FD	0x430D	
TX_CFG1_LANE0	16-bit Hex	0x0033	0x400E	0x800E – 0x01
TX_CFG1_LANE1		0x0083	0x410E	
TX_CFG1_LANE2		0x00BB	0x420E	
TX_CFG1_LANE3		0x00FE	0x430E	
TX_CFG2_LANE0	16-bit Hex	0x0034	0x400F	0x800F – 0x01
TX_CFG2_LANE1		0x0084	0x410F	
TX_CFG2_LANE2		0x00BC	0x420F	
TX_CFG2_LANE3		0x00FF	0x430F	
TX_CLK_SEL0_LANE0	16-bit Hex	0x0036	0x4011	0x8011 – 0x01
TX_CLK_SEL0_LANE1		0x0086	0x4111	
TX_CLK_SEL0_LANE2		0x00BE	0x4211	
TX_CLK_SEL0_LANE3		0x0101	0x4311	
TX_CLK_SEL1_LANE0	16-bit Hex	0x0037	0x4012	0x8012 – 0x01
TX_CLK_SEL1_LANE1		0x0087	0x4112	
TX_CLK_SEL1_LANE2		0x00BF	0x4212	
TX_CLK_SEL1_LANE3		0x0102	0x4312	
TX_DISABLE_LANE0	16-bit Hex	0x000A	0x2009	0x0009 – 0x01
TX_DISABLE_LANE1		0x0070	0x2109	
TX_DISABLE_LANE2		0x00A8	0x2209	
TX_DISABLE_LANE3		0x00E4	0x2309	

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Table A-1: **GTH_QUAD Attributes *(Cont'd)***

Attribute Name	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
TX_FABRIC_WIDTH0	Integer	0x004E[15:13]	N/A	N/A
TX_FABRIC_WIDTH1		0x0051[15:13]		
TX_FABRIC_WIDTH2		0x00F1[15:13]		
TX_FABRIC_WIDTH3		0x00EE[15:13]		
TX_P0P0S_CTRL	16-bit Hex	0x001E	0x6018	0xC018 – 0x01
TX_P1P2_CTRL	16-bit Hex	0x001F	0x6019	0xC019 – 0x01
TX_PREEMPH_LANE0	16-bit Hex	0x0035	0x4010	0x8010 – 0x01
TX_PREEMPH_LANE1		0x0085	0x4110	
TX_PREEMPH_LANE2		0x00BD	0x4210	
TX_PREEMPH_LANE3		0x0100	0x4310	
TX_PWR_RATE_OVRD_LANE0	16-bit Hex	0x003C	0x401D	0x801D – 0x01
TX_PWR_RATE_OVRD_LANE1		0x008C	0x411D	
TX_PWR_RATE_OVRD_LANE2		0x00C4	0x421D	
TX_PWR_RATE_OVRD_LANE3		0x0107	0x431D	

Table A-2: **GTH QUAD Read-Only Registers**

Read-only Registers	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
RAW_SHIFT_MON_LANE0	16-bit Hex	N/A	0x500E	0x800E – 0x03
RAW_SHIFT_MON_LANE1			0x510E	
RAW_SHIFT_MON_LANE2			0x520E	
RAW_SHIFT_MON_LANE3			0x530E	
PRBS_ERR_CNT0_LANE0	16-bit Hex	N/A	0x5002	0x8002 – 0x03
PRBS_ERR_CNT0_LANE1			0x5102	
PRBS_ERR_CNT0_LANE2			0x5202	
PRBS_ERR_CNT0_LANE3			0x5302	
PRBS_ERR_CNT1_LANE0	16-bit Hex	N/A	0x5003	0x8003 – 0x03
PRBS_ERR_CNT1_LANE1			0x5103	
PRBS_ERR_CNT1_LANE2			0x5203	
PRBS_ERR_CNT1_LANE3			0x5303	

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Table A-2: **GTH QUAD Read-Only Registers *(Cont'd)***

Read-only Registers	Type	Configuration Memory (DRP Address)	GTH Registers (DRP Address)	GTH Registers (MGMT with MMD Address)
PRBS_TIMER_0_LANE0	16-bit Hex	N/A	0x5004	0x8004 – 0x03
PRBS_TIMER_0_LANE1			0x5104	
PRBS_TIMER_0_LANE2			0x5204	
PRBS_TIMER_0_LANE3			0x5304	
PRBS_TIMER_1_LANE0	16-bit Hex	N/A	0x5005	0x8005– 0x03
PRBS_TIMER_1_LANE1			0x5105	
PRBS_TIMER_1_LANE2			0x5205	
PRBS_TIMER_1_LANE3			0x5305	
PRBS_TIMER_2_LANE0	16-bit Hex	N/A	0x5006	0x8006 – 0x03
PRBS_TIMER_2_LANE1			0x5106	
PRBS_TIMER_2_LANE2			0x5206	
PRBS_TIMER_2_LANE3			0x5306	

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