

# **RXAUI v4.3**

## ***LogiCORE IP Product Guide***

**Vivado Design Suite**

**PG083 October 5, 2016**

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## Introduction

The LogiCORE™ IP RXAUI core is a high-performance, low pin count 10 Gb/s interface intended to allow physical separation between the data-link layer and physical layer devices in a 10 Gb/s Ethernet system.

The RXAUI core implements a single-speed full-duplex 10 Gb/s Ethernet Reduced Pin eXtended Attachment Unit Interface (RXAUI) solution for Xilinx® 7 series FPGAs and UltraScale architecture (GTHE3 transceivers) that comply with Dune Networks specifications.

The 7 series FPGA and UltraScale architecture in combination with the RXAUI core, enable the design of RXAUI-based interconnects whether they are chip-to-chip, over backplanes, or connected to 10 Gb/s optical modules.

## Features

- Designed to Dune Networks specifications
- Uses two transceivers at 6.25 Gb/s line rate to achieve 10 Gb/s data rate
- Implements DTE XGXS, PHY XGXS, and 10GBASE-X PCS in a single encrypted HDL
- *IEEE 802.3-2012* clause 45 MDIO interface (optional)
- Available under the [Xilinx End User License Agreement](#)

LogiCORE IP Facts Table	
<b>Core Specifics</b>	
Supported Device Family <sup>(1)</sup>	UltraScale+™ UltraScale™ Zynq®-7000 All Programmable SoC 7 Series
Supported User Interfaces	XGMII, MDIO
Resources	<a href="#">Performance and Resource Utilization web page</a>
<b>Provided with Core</b>	
Design Files	Encrypted RTL
Example Design	Verilog/VHDL
Test Bench	Verilog/VHDL
Constraints File	XDC
Simulation Model	VHDL/Verilog
Supported S/W Driver	N/A
<b>Tested Design Flows<sup>(2)</sup></b>	
Design Entry	Vivado® Design Suite
Simulation	For supported simulators, see the <a href="#">Xilinx Design Tools: Release Notes Guide</a> .
Synthesis	Vivado Synthesis
<b>Support</b>	
Provided by Xilinx at the <a href="#">Xilinx Support web page</a>	

### Notes:

1. For a complete listing of supported devices, see the Vivado IP catalog.
2. For the supported versions of the tools, see the [Xilinx Design Tools: Release Notes Guide](#).

## Overview

The RXAUI standard was developed as a means to improve the 10-Gigabit Ethernet port density. The number of XAUI interfaces that could be implemented was limited by the number of available transceivers, with capacity and performance still to be utilized. RXAUI halves the number of transceivers required compared with a XAUI implementation.

RXAUI is a two-lane, 6.25 Gb/s-per-lane serial interface. It is intended to work with an existing XAUI implementation and multiplexes/demultiplexes the two physical RXAUI lanes into four logical XAUI lanes. Each RXAUI lane is a differential pair carrying current mode logic (CML) signaling, and the data on each lane is 8B/10B encoded before transmission.

In this document:

- Virtex®-7 and Kintex®-7 FPGAs GTX transceivers are abbreviated to GTX transceivers.
- Virtex-7 FPGA GTH transceiver is abbreviated to GTH transceiver.
- Artix®-7 FPGA GTP transceiver is abbreviated to GTP transceiver.
- UltraScale architecture transceiver is abbreviated to UltraScale transceiver.

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## Feature Summary

The RXAUI core can be configured in the following mode for Dune Networks. This RXAUI implementation maintains 8B/10B disparity on the RXAUI physical lane. The Dune Networks RXAUI standard is fully specified in DN-DS-RXAUI-Spec v.1.0.

For the management interface, the RXAUI core can be customized with either a two-wire low-speed serial MDIO interface, or a configuration and status vector interface.

## Applications

The applications of RXAUI have extended beyond 10-Gigabit Ethernet to the backplane and other general high-speed interconnect applications. A typical backplane application is shown in [Figure 1-1](#).

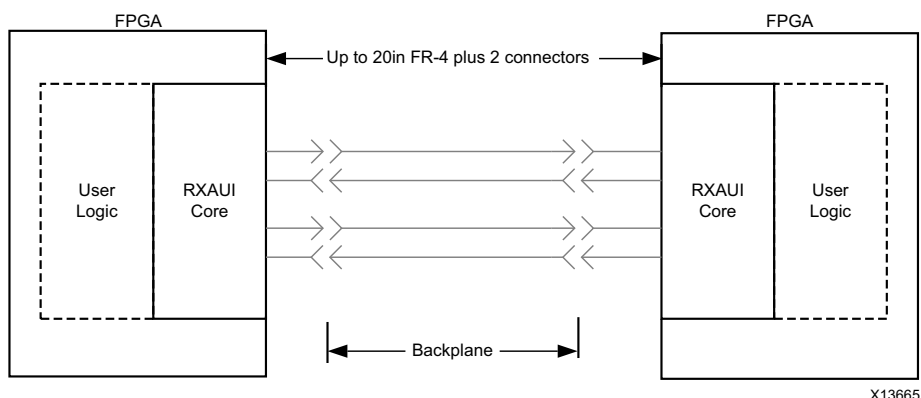


Figure 1-1: Typical Backplane Application for RXAUI

## Functional Description

[Figure 1-2](#) shows a block diagram of the Dune Networks RXAUI core implementation. The major functional blocks of the core include the following:

- **Transmit Idle Generation Logic** – Creates the code groups to allow synchronization and alignment at the receiver.
- **Demux Logic** – Separates the two physical RXAUI lanes into four logical XAUI lanes.
- **Synchronization State Machine (one per lane)** – Identifies byte boundaries in incoming serial data.
- **Deskew State Machine** – Deskews the four received lanes into alignment.
- **Optional MDIO Interface** – A two-wire low-speed serial interface used to manage the core.
- **Embedded Transceivers** – Provide high-speed transceivers as well as 8B/10B encode and decode, and elastic buffering in the receive datapath.

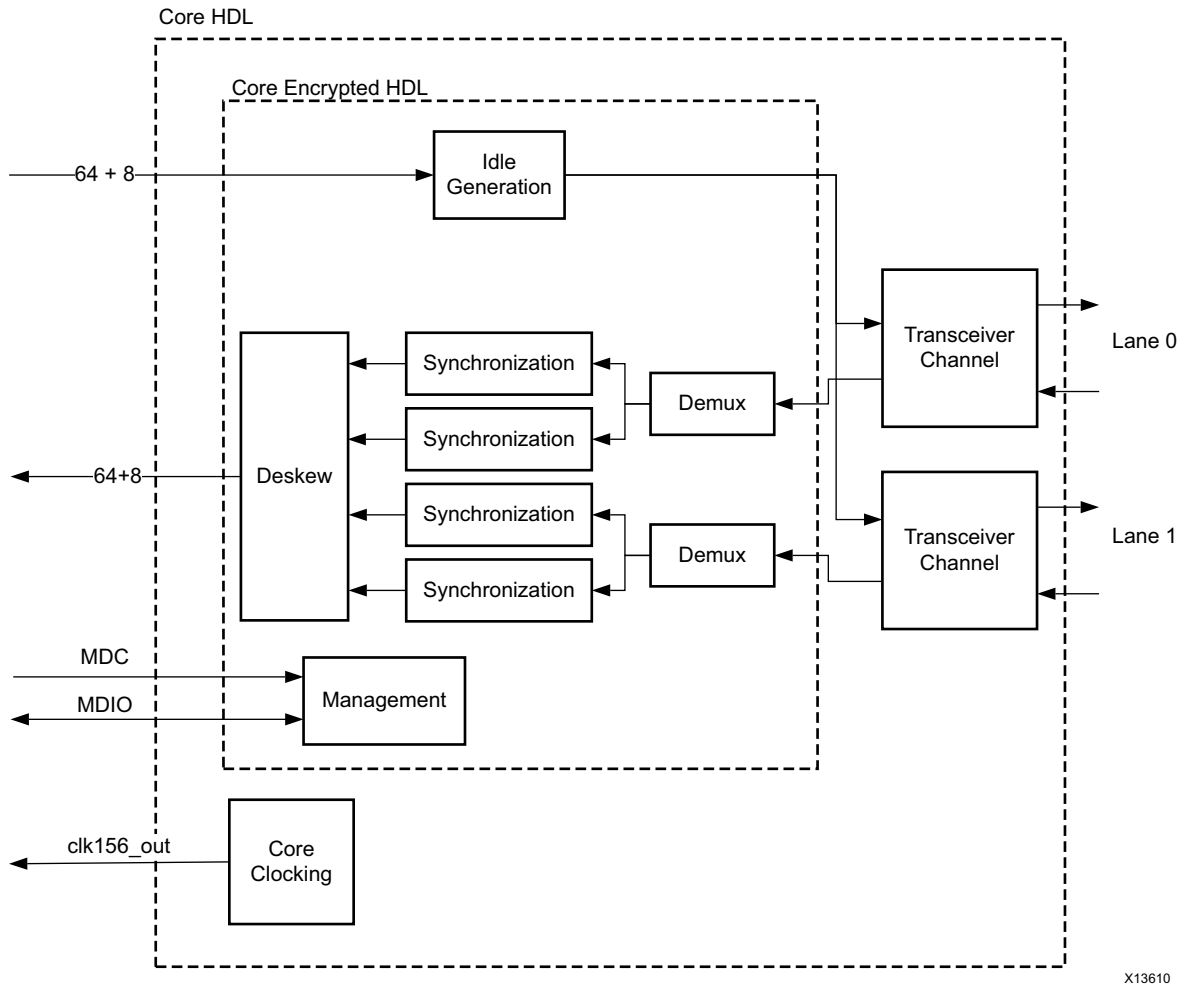


Figure 1-2: Implementation of Dune Networks RXAUI Core

## Licensing and Ordering Information

This Xilinx® LogiCORE™ IP module is provided at no additional cost with the Xilinx Vivado® Design Suite under the terms of the [Xilinx End User License](#). Information about this and other Xilinx LogiCORE IP modules is available at the [Xilinx Intellectual Property](#) page. For information about pricing and availability of other Xilinx LogiCORE IP modules and tools, contact your [local Xilinx sales representative](#).

# Product Specification

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## Standards

The LogiCORE™ IP RXAUI core is designed to the Dune Networks [\[Ref 1\]](#) specifications.

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## Performance

### Latency

These measurements are for the core only — they do not include the latency through the transceiver. The latency through the transceiver can be obtained from the relevant user guide.

#### *Transmit Path Latency*

As measured from the input port `xgmii_txd[63:0]` of the transmitter side XGMII (until that data appears on `mgt_txdata[63:0]` on the internal transceiver interface), the latency through the core for the internal XGMII interface configuration in the transmit direction is 4 clock periods of the core input `usrclk` for Dune Networks mode.

#### *Receive Path Latency*

Measured from the transceiver output pins `RXDATA[63:0]` until the data appears on `xgmii_rxddata[63:0]` of the receiver side XGMII interface, the latency through the core in the receive direction for Dune Networks mode is equal to six to eight clock cycles of `usrclk`. The latency depends on comma alignment position and data positioning within the transceiver 4-byte interface.



## Resource Utilization

For full details about performance and resource utilization, visit the [Performance and Resource Utilization web page](#).

## Port Descriptions

### Client-Side Interface

The signals of the client-side interface are shown in [Table 2-1](#). See [Protocol Description](#) for details on connecting to the client-side interface.

*Table 2-1: Client-Side Interface Ports*

Signal Name	Direction	Clock Domain	Description
xgmii_txd[63:0]	In	clk156_out	Transmit data, 8 bytes wide
xgmii_txc[7:0]	In	clk156_out	Transmit control bits, 1-bit per transmit data byte
xgmii_rxd[63:0]	Out	clk156_out	Received data, 8 bytes wide
xgmii_rxc[7:0]	Out	clk156_out	Receive control bits, 1-bit per received data byte

### Transceiver Interface

The following signals are directly connected to the transceiver instance.

*Table 2-2: Transceiver Interface Ports*

Signal Name	Direction	Clock Domain	Description
rxau_i_tx_l0_p, rxau_i_tx_l0_n, rxau_i_tx_l1_p, rxau_i_tx_l1_n	Out	N/A	Differential complements of one another forming a differential transmit output pair. One pair for each of the 2 lanes.
rxau_i_rx_l0_p, rxau_i_rx_l0_n, rxau_i_rx_l1_p, rxau_i_rx_l1_n	In	N/A	Differential complements of one another forming a differential receiver input pair. One pair for each of the 2 lanes.
signal_detect[1:0]	In	Async	Intended to be driven by an attached optical module; they signify that each of the two optical receivers is receiving illumination and is therefore not just putting out noise. If an optical module is not in use, this 2-wire bus should be tied to 0x3.

## MDIO Ports

The RXAUI core, when generated with an MDIO interface, implements an MDIO Interface Register block. The core responds to MDIO transactions as either a 10GBASE-X PCS, a DTE XS, or a PHY XS depending on the setting of the `type_sel` port (see [Table 3-3](#)). The MDIO Interface Ports are described in [Table 2-3](#). More information about using this interface can be found in [MDIO Interface](#).

**Table 2-3: MDIO Management Interface Ports**

Signal Name	Direction	Clock Domain	Description
mdc	In	Async	Management clock
mdio_in	In	Async	MDIO input
mdio_out	Out	clk156_out	MDIO output
mdio_tri	Out	clk156_out	MDIO 3-state. 1 disconnects the output driver from the MDIO bus.
type_sel[1:0]	In	clk156_out	Type select
prtad[4:0]	In	clk156_out	MDIO port address

## Configuration and Status Signals

The Configuration and Status Signals are shown in [Table 2-16](#). See [Configuration and Status Vectors](#) for details on these signals, including a breakdown of the configuration and status vectors.

**Table 2-4: Configuration and Status Ports**

Signal Name	Direction	Clock Domain	Description
configuration_vector[6:0]	In	clk156_out	Configuration information for the core.
status_vector[7:0]	Out	clk156_out	Status information from the core.

## Clocking and Reset Signals and Module

Included in the example design sources are circuits for clock and reset management. For the RXAUI core these comprise the transceiver Quad PLL and associated reset logic. [Tables 2-5 to 2-9](#) shows the ports on the core that are associated with system clocks and resets.

**Table 2-5: Clocking and Reset Ports**

Signal Name	Direction	Description
clk156_out	Out	156.25 MHz clock derived from TXOUTCLK. Can be used for external logic. Cannot be connected to another RXAUI core.
clk156_lock	In	Indicates that clk156_out is stable and ready for use.

Table 2-5: Clocking and Reset Ports (Cont'd)

Signal Name	Direction	Description
dclk	In	<p>Clock used as the DRP clock, and also as a stable reference clock for the detection of the feedback and reference clock signals to the QPLL. The input reference clock to the QPLL or any output clock generated from the QPLL (for example, TXOUTCLK) must not be used to drive this clock.</p> <p>For UltraScale devices, this clock is also used in the internal state machines for the configuration of the transceiver.</p>
reset	In	Asynchronous reset connected to the transceiver Channel PLL or transceiver Quad PLL. This should be asserted if refclk or dclk is not valid.

Table 2-6: 7 Series and Zynq-7000 GTX and GTH Clocking Ports - Shared Logic Included in Example Design

Signal Name	Direction	Description
refclk	In	Transceiver reference clock. Must be driven from the appropriate transceiver differential clock buffer.
qplloutclk	In	Connect to the quad PLL output clock QPLLOUTCLK.
qplllock	In	Connect to the quad PLL lock output QPLLLOCK.
qplloutrefclk	In	Connect to the quad PLL output reference clock QPLLOUTREFCLK.

Table 2-7: Artix-7 and Zynq-7000 GTP Clocking Ports - Shared Logic Included in Example Design

Signal Name	Direction	Description
common_pll_reset	In	Connect to the reset to the GTPE2_COMMON PLL.
pll0outclk	In	Connect to the GTPE2_COMMON PLL port PLL0OUTCLK.
pll0lock	In	Connect to the GTPE2_COMMON PLL lock port PLL0LOCK.
pll0outrefclk	In	Connect to the GTPE2_COMMON PLL REFCLK port PLL0OUTREFCLK.
pll1outclk	In	Connect to the GTPE2_COMMON PLL port PLL1OUTCLK.
pll1outrefclk	In	Connect to the GTPE2_COMMON PLL REFCLK port PLL1OUTREFCLK.

Table 2-8: 7 Series and Zynq-7000 GTX and GTH Clocking Ports - Shared Logic Included in Core

Signal Name	Direction	Description
refclk_p	In	Differential transceiver reference clock p.
refclk_n	In	Differential transceiver reference clock n.
refclk_out	Out	Reference clock output from the differential transceiver clock buffer.
qplloutclk_out	Out	Output from the quad PLL port QPLLOUTCLK.

**Table 2-8: 7 Series and Zynq-7000 GTX and GTH Clocking Ports - Shared Logic Included in Core**

Signal Name	Direction	Description
qplllock_out	Out	Output from the quad PLL port QPLLLOCK.
qpllrefclk_out	Out	Output from the quad PLL port QPLLREFCLK.

**Table 2-9: Artix-7 and Zynq-7000 GTP Clocking Ports - Shared Logic Included in Core**

Signal Name	Direction	Description
common_pll_reset_out	Out	Output reset signal to the GTPE2_COMMON PLL and associated transceivers.
pll0outclk_out	Out	Output from the GTPE2_COMMON PLL port PLL0OUTCLK.
pll0lock_out	Out	Output from the GTPE2_COMMON PLL port PLL0LOCK.
pll0outrefclk_out	Out	Output from the GTPE2_COMMON PLL port PLL0OUTREFCLK.
pll1outclk_out	Out	Output from the GTPE2_COMMON PLL port PLL1OUTCLK.
pll1outrefclk_out	Out	Output from the GTPE2_COMMON PLL port PLL1OUTREFCLK.

Tables 2-10 to 2-11 shows the UltraScale ports on the core that are associated with system clocks and resets.

**Table 2-10: UltraScale Clocking Ports - Shared Logic Included in Example Design**

Signal Name	Direction	Description
refclk	In	Transceiver reference clock. Must be driven from the appropriate transceiver differential clock buffer.
qpll0outclk	In	Connect to the quad PLL output clock QPLL0OUTCLK.
qpll0lock	In	Connect to the quad PLL lock output QPLL0LOCK.
qpll0outrefclk	In	Connect to the quad PLL output reference clock QPLL0OUTREFCLK.
qpll0reset	Out	QPLL reset signal from the UltraScale GT Wizard reset logic.

**Table 2-11: UltraScale Clocking Ports - Shared Logic Included in Core**

Signal Name	Direction	Description
refclk_p	In	Differential transceiver reference clock p.
refclk_n	vIn	Differential transceiver reference clock n.
refclk	Out	Reference clock output from the differential transceiver clock buffer.
qpll0outclk_out	Out	Output from the quad PLL port QPLL0OUTCLK.
qpll0lock_out	Out	Output from the quad PLL port QPLL0LOCK.
qpll0outrefclk_out	Out	Output from the quad PLL port QPLL0OUTREFCLK.

## Transceiver Control and Status

The transceiver interface is present if the **Additional Transceiver Control and Status Ports** option is selected. There are a number of ports that are directly connected to the transceivers. For a complete description of these signals, see the appropriate transceiver user guide (*7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [Ref 2], *7 Series FPGAs GTP Transceivers User Guide* (UG482) [Ref 3], the *UltraScale Architecture GTH Transceivers User Guide* (UG576) [Ref 4] and the *UltraScale Architecture GTY Transceivers User Guide* (UG578) [Ref 5]). Table 2-12 and Table 2-13 lists the ports for 7 series FPGAs. Ports are prefixed with GT0 for transceiver 0 and GT1 for transceiver 1.



**IMPORTANT:** The ports in the Transceiver Control And Status interface must be driven in accordance with the appropriate GT user guide. Using the input signals listed in Table 2-13 might result in unpredictable behavior of the IP core.

Table 2-12: Transceiver Control and Status Ports (Channel 0)—7 Series FPGAs

Signal Name	I/O	Clock Domain	Description
<b>GT0 DRP</b>			
gt0_drpaddr[8:0]	In	dclk	DRP address bus for channel 0
gt0_drpen	In	dclk	DRP enable signal. 0: No read or write operation performed. 1: enables a read or write operation.
gt0_drpdi[15:0]	In	dclk	Data bus for writing configuration data to the transceiver for channel 0.
gt0_drpdo[15:0]	Out	dclk	Data bus for reading configuration data from the transceiver for channel 0.
gt0_drprdy	Out	dclk	Indicates operation is complete for write operations and data is valid for read operations for channel 0.
gt0_drpwe	In	dclk	DRP write enable for channel 0. 0: Read operation when drpen is 1. 1: Write operation when drpen is 1.
gt0_drp_busy	Out	dclk	(GTPE2 all configurations or GTHE2 10G configuration). Indicates the DRP interface is being used internally by the serial transceiver and should not be driven until this signal is deasserted.
<b>GT0 TX Reset and Initialization</b>			
gt0_txpmareset_in	In	Async	Starts the TX PMA reset process.
gt0_txpcsreset_in	In	Async	Starts the TX PCS reset process.
gt0_txresetdone_out	Out	clk156_out	When asserted the serial transceiver TX has finished reset and is ready for use.
<b>GT0 RX Reset and Initialization</b>			
gt0_rxpmareset_in	In	Async	Starts the RX PMA reset process.
gt0_rxpcsreset_in	In	Async	Starts the RX PCS reset process.

Table 2-12: Transceiver Control and Status Ports (Channel 0)—7 Series FPGAs (Cont'd)

Signal Name	I/O	Clock Domain	Description
gt0_rxpmaresetdone_out	Out	Async	(GTHE2 and GTPE2) This active-High signal indicates RX PMA reset is complete.
gt0_rxresetdone_out	Out	clk156_out	When asserted the serial transceiver RX has finished reset and is ready for use.
<b>GT0 Clocking</b>			
gt0_rxbufstatus_out[2:0]	Out	clk156_out	RX buffer status.
gt0_txphaligndone_out	Out	Async	TX phase alignment done.
gt0_txphinitdone_out	Out	Async	TX phase alignment initialization done.
gt0_txdlysresetdone_out	Out	Async	TX delay alignment soft reset done.
gt0_cpplllock_out	Out	Async	(GTHE2) This active-High PLL frequency lock signal indicates that the PLL frequency is within predetermined tolerance.
gt_qplllock_out	Out	Async	(GTXE2 and GTPE2) This active-High PLL frequency lock signal indicates that the PLL frequency is within predetermined tolerance.
<b>Signal Integrity and Functionality</b>			
<b>GT0 Eye scan</b>			
gt0_eyesctrigger_in	In	clk156_out	Causes a trigger event.
gt0_eyescanreset_in	In	Async	This port is driven High and then deasserted to start the EYESCAN reset process.
gt0_eyescanerror_out	Out	Async	Asserts High for one <i>rec_clk</i> cycle when an (unmasked) error occurs while in the COUNT or ARMED state.
gt0_rxrate_in[2:0]	In	Reserved	This port dynamically controls the setting for the RX serial clock divider.
<b>GT0 Loopback</b>			
gt0_loopback_in[2:0]	In	Async	Determines the loopback mode.
<b>GT0 Polarity</b>			
gt0_rxpolarity_in	In	clk156_out	The rxpolarity port can invert the polarity of incoming data.
gt0_txpolarity_in	In	clk156_out	The txpolarity port can invert the polarity of outgoing data.
<b>GT0 RX Decision Feedback Equalizer (DFE)</b>			
gt0_rxlpmen_in	In	Async	(GTXE2 and GTHE2) RX datapath. 0: DFE. 1: LPM.
gt0_rxdfelpmreset_in	In	Async	(GTXE2 and GTHE2) Reset for LPM and DFE datapath.
gt0_rxmonitorsel_in[1:0]	In	Reserved	(GTXE2 and GTHE2) Select signal for <i>gt0_rxmonitorout_out</i> .

Table 2-12: Transceiver Control and Status Ports (Channel 0)—7 Series FPGAs (Cont'd)

Signal Name	I/O	Clock Domain	Description
gt0_rxmonitorout_out[6:0]	Out	Async	(GTXE2 and GTHE2) Monitor output.
gt0_rxlpmreset_in	In	clk156_out	(GTPE2) This port is driven High and then deasserted to start the LPM reset process.
gt0_rxlpmhfhold_in	In	Async	(GTPE2) Determines whether the value of the high-frequency boost is either held or adapted.
gt0_rxlpmhfvrden_in	In	Async	(GTPE2) Determines whether the high-frequency boost is controlled by an attribute or a signal.
gt0_rxlpmfhold_in	In	Async	(GTPE2) Determines whether the value of the low-frequency boost is either held or adapted.
gt0_rxlpmfvrden_in	In	Async	(GTPE2) Determines whether the low-frequency boost is controlled by an attribute or a signal.
<b>GT0 TX Driver</b>			
gt0_txpostcursor_in[4:0]	In	Async	Transmitter post-cursor TX post-emphasis control.
gt0_txprecursor_in[4:0]	In	Async	Transmitter post-cursor TX pre-emphasis control.
gt0_txdifctrl_in[3:0]	In	Async	Driver Swing Control.
gt0_txinhibit_in	In	clk156_out	When High, this signal blocks the transmission of data.
<b>GT0 PRBS</b>			
gt0_rxprbscntreset_in	In	clk156_out	Resets the PRBS error counter.
gt0_rxprbserr_out	Out	clk156_out	This non-sticky status output indicates that PRBS errors have occurred.
gt0_rxprbssel_in[2:0]	In	clk156_out	Receiver PRBS checker test pattern control.
gt0_txprbssel_in[2:0]	In	clk156_out	Transmitter PRBS generator test pattern control.
gt0_txprbsforceerr_in	In	clk156_out	When this port is driven High, errors are forced in the PRBS transmitter. While this port is asserted, the output data pattern contains errors.
<b>GT0 RX CDR</b>			
gt0_rxcdrhold_in	In	Async	Hold the CDR control loop frozen.
<b>GT0 Digital Monitor</b>			
gt0_dmonitorout_out[7:0]	Out	Async	(GTXE2) Digital Monitor Output Bus
gt0_dmonitorout_out[14:0]	Out	Async	(GTHE2) Digital Monitor Output Bus
gt0_dmonitorout_out[14:0]	Out	Async	(GTPE2) Digital Monitor Output Bus
<b>GT0 Status</b>			
gt0_rxdisperr_out[3:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data has a disparity error

Table 2-12: Transceiver Control and Status Ports (Channel 0)—7 Series FPGAs (Cont'd)

Signal Name	I/O	Clock Domain	Description
gt0_rxnotintable_out[3:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data was not a valid character in the 8B/10B table.
gt0_rxcommadet_out	Out	clk156_out	This signal is asserted when the comma alignment block detects a comma.

Table 2-13: Transceiver Control and Status Ports (Channel 1)—7 Series FPGAs

Signal Name	I/O	Clock Domain	Description
<b>GT1 DRP</b>			
gt1_drpaddr[8:0]	In	dclk	DRP address bus for channel 1.
gt1_drpen	In	dclk	DRP enable signal. 0: No read or write operation performed. 1: enables a read or write operation.
gt1_drpdi[15:0]	In	dclk	Data bus for writing configuration data to the transceiver for channel 1.
gt1_drpdo[15:0]	Out	dclk	Data bus for reading configuration data from the transceiver for channel 1.
gt1_drprdy	Out	dclk	Indicates operation is complete for write operations and data is valid for read operations for channel 1.
gt1_drpwe	In	dclk	DRP write enable for channel 1. 0: Read operation when drpen is 1. 1: Write operation when drpen is 1.
gt1_drp_busy	Out	dclk	(GTPE2 all configurations or GTHE2 10G configuration). Indicates the DRP interface is being used internally by the serial transceiver and should not be driven until this signal is deasserted.
<b>GT1 TX Reset and Initialization</b>			
gt1_txpmareset_in	In	Async	Starts the TX PMA reset process.
gt1_txpcsreset_in	In	Async	Starts the TX PCS reset process.
gt1_txresetdone_out	Out	clk156_out	When asserted the serial transceiver TX has finished reset and is ready for use.
<b>GT1 RX Reset and Initialization</b>			
gt1_rxpmareset_in	In	Async	Starts the RX PMA reset process.
gt1_rxpcsreset_in	In	Async	Starts the RX PCS reset process.
gt1_rxpmaresetdone_out	Out	Async	(GTPE2 and GTHE2) This active-High signal indicates RX PMA reset is complete.
gt1_rxresetdone_out	Out	clk156_out	When asserted the serial transceiver RX has finished reset and is ready for use.



Table 2-13: Transceiver Control and Status Ports (Channel 1)—7 Series FPGAs (Cont'd)

Signal Name	I/O	Clock Domain	Description
<b>GT1 Clocking</b>			
gt1_rxbufstatus_out[2:0]	Out	clk156_out	RX buffer status.
gt1_txphaligndone_out	Out	Async	TX phase alignment done.
gt1_txphinitdone_out	Out	Async	TX phase alignment initialization done.
gt1_txdlysresetdone_out	Out	Async	TX delay alignment soft reset done.
gt1_cpplllock_out	Out	Async	(GTHE2) This active-High PLL frequency lock signal indicates that the PLL frequency is within predetermined tolerance.
<b>Signal Integrity and Functionality</b>			
<b>GT1 Eye scan</b>			
gt1_eyesctrigger_in	In	clk156_out	Causes a trigger event.
gt1_eyescanreset_in	In	Async	This port is driven High and then deasserted to start the EYESCAN reset process.
gt1_eyescanataerror_out	Out	Async	Asserts High for one <code>rec_clk</code> cycle when an (unmasked) error occurs while in the COUNT or ARMED state.
gt1_rxrate_in[2:0]	In	Reserved	This port dynamically controls the setting for the RX serial clock divider.
<b>GT1 Loopback</b>			
gt1_loopback_in[2:0]	In	Async	Determines the loopback mode.
<b>GT1 Polarity</b>			
gt1_rxpolarity_in	In	clk156_out	The rxpolarity port can invert the polarity of incoming data.
gt1_txpolarity_in	In	clk156_out	The txpolarity port can invert the polarity of outgoing data.
<b>GT1 RX Decision Feedback Equalizer (DFE)</b>			
gt1_rxlpmen_in	In	Async	(GTXE2 and GTHE2) RX datapath. 0: DFE. 1: LPM.
gt1_rxdfelpmreset_in	In	Async	(GTXE2 and GTHE2) Reset for LPM and DFE datapath.
gt1_rxmonitorssel_in[1:0]	In	Reserved	(GTXE2 and GTHE2) Select signal for gt1_rxmonitorout_out.
gt1_rxmonitorout_out[6:0]	Out	Async	(GTXE2 and GTHE2) Monitor output.
gt1_rxlpmreset_in	In	clk156_out	(GTPE2) This port is driven High and then deasserted to start the LPM reset process.
gt1_rxlpmhfhold_in	In	Async	(GTPE2) Determines whether the value of the high-frequency boost is either held or adapted.
gt1_rxlpmhfvrden_in	In	Async	(GTPE2) Determines whether the high-frequency boost is controlled by an attribute or a signal.

Table 2-13: Transceiver Control and Status Ports (Channel 1)—7 Series FPGAs (Cont'd)

Signal Name	I/O	Clock Domain	Description
gt1_rxlpmfhold_in	In	Async	(GTPE2) Determines whether the value of the low-frequency boost is either held or adapted.
gt1_rxlpmfivrden_in	In	Async	(GTPE2) Determines whether the low-frequency boost is controlled by an attribute or a signal.
<b>GT1 TX Driver</b>			
gt1_txpostcursor_in[4:0]	In	Async	Transmitter post-cursor TX post-emphasis control.
gt1_txprecursor_in[4:0]	In	Async	Transmitter post-cursor TX pre-emphasis control.
gt1_txdiffctrl_in[3:0]	In	Async	Driver Swing Control.
gt1_txinhibit_in	In	clk156_out	When High, this signal blocks the transmission of data.
<b>GT1 PRBS</b>			
gt1_rxprbsctrlreset_in	In	clk156_out	Resets the PRBS error counter.
gt1_rxprbserr_out	Out	clk156_out	This non-sticky status output indicates that PRBS errors have occurred.
gt1_rxprbsctrl_in[2:0]	In	clk156_out	Receiver PRBS checker test pattern control.
gt1_txprbsctrl_in[2:0]	In	clk156_out	Transmitter PRBS generator test pattern control.
gt1_txprbsforceerr_in	In	clk156_out	When this port is driven High, errors are forced in the PRBS transmitter. While this port is asserted, the output data pattern contains errors.
<b>GT1 RX CDR</b>			
gt1_rxcdrhold_in	In	Async	Hold the CDR control loop frozen.
<b>GT1 Digital Monitor</b>			
gt1_dmonitorout_out[7:0]	Out	Async	(GTXE2) Digital Monitor Output Bus
gt1_dmonitorout_out[14:0]	Out	Async	(GTHE2) Digital Monitor Output Bus
gt1_dmonitorout_out[14:0]	Out	Async	(GTPE2) Digital Monitor Output Bus
<b>GT1 Status</b>			
gt1_rxdisperr_out[3:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data has a disparity error
gt1_rxnotintable_out[3:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data was not a valid character in the 8B/10B table.
gt1_rxcommadet_out	Out	clk156_out	This signal is asserted when the comma alignment block detects a comma.

Table 2-14 lists the ports for UltraScale devices.

Table 2-14: Transceiver Control and Status Ports — UltraScale Architectures

Signal Name	Direction	Clock Domain	Description
<b>GT0 DRP</b>			
gt0_drpaddr[8:0]	In	dclk	DRP address bus for channel 0
gt0_drpen	In	dclk	DRP enable signal. 0: No read or write operation performed. 1: enables a read or write operation.
gt0_drpdi[15:0]	In	dclk	Data bus for writing configuration data to the transceiver for channel 0.
gt0_drpdo[15:0]	Out	dclk	Data bus for reading configuration data from the transceiver for channel 0.
gt0_drprdy	Out	dclk	Indicates operation is complete for write operations and data is valid for read operations for channel 0.
gt0_drpwe	In	dclk	DRP write enable for channel 0. 0: Read operation when drpen is 1. 1: Write operation when drpen is 1.
<b>GT1 DRP</b>			
gt1_drpaddr[8:0]	In	dclk	DRP address bus for channel 1
gt1_drpen	In	dclk	DRP enable signal. 0: No read or write operation performed. 1: enables a read or write operation.
gt1_drpdi[15:0]	In	dclk	Data bus for writing configuration data to the transceiver for channel 1.
gt1_drpdo[15:0]	Out	dclk	Data bus for reading configuration data from the transceiver for channel 1.
gt1_drprdy	Out	dclk	Indicates operation is complete for write operations and data is valid for read operations for channel 1.
gt1_drpwe	In	dclk	DRP write enable for channel 1. 0: Read operation when drpen is 1. 1: Write operation when drpen is 1.
<b>DRP Reset</b>			
gt_pcsrsvdin[31:0]	In	Async	Bits 2 and 18 are connected to port pcsrsvdin[2] of GT lanes 0 and 1 respectively. See the appropriate transceiver user guide for more details.

Table 2-14: Transceiver Control and Status Ports — UltraScale Architectures (Cont'd)

Signal Name	Direction	Clock Domain	Description
<b>TX Reset and Initialization</b>			
gt_txpmareset[1:0]	In	Async	Starts the TX PMA reset process.
gt_txpcsreset[1:0]	In	Async	Starts the TX PCS reset process.
gt_txresetdone[1:0]	Out	clk156_out	When asserted the serial transceiver TX has finished reset and is ready for use.
<b>RX Reset and Initialization</b>			
gt_rxpmareset[1:0]	In	Async	Starts the RX PMA reset process.
gt_rxpcsreset[1:0]	In	Async	Starts the RX PCS reset process.
gt_rxpmaresetdone[1:0]	Out	Async	
gt_rxresetdone[1:0]	Out	clk156_out	When asserted the serial transceiver RX has finished reset and is ready for use.
<b>Clocking</b>			
gt_rxbufstatus[5:0]	Out	clk156_out	RX buffer status.
gt_txphaligndone[1:0]	Out	Async	TX phase alignment done.
gt_txphinitdone[1:0]	Out	Async	TX phase alignment initialization done.
gt_txdlysresetdone[1:0]	Out	Async	TX delay alignment soft reset done.
gt_qplllock	Out	Async	This active-High PLL frequency lock signal indicates that the PLL frequency is within predetermined tolerance.
<b>Signal Integrity and Functionality</b>			
<b>Eye Scan</b>			
gt_eyescantrigger[1:0]	In	clk156_out	Causes a trigger event.
gt_eyescanreset[1:0]	In	Async	This port is driven High and then deasserted to start the EYESCAN reset process.
gt_eyescanataerror[1:0]	Out	Async	Asserts High for one rec_clk cycle when an (unmasked) error occurs while in the COUNT or ARMED state.
gt_rxrate[5:0]	In	clk156_out	This port dynamically controls the setting for the RX serial clock divider.
<b>Loopback</b>			
gt_loopback[5:0]	In	Async	Determines the loopback mode.
<b>Polarity</b>			
gt_rxpolarity[1:0]	In	clk156_out	The rxpolarity port can invert the polarity of incoming data.
gt_txpolarity[1:0]	In	clk156_out	The txpolarity port can invert the polarity of outgoing data.

Table 2-14: Transceiver Control and Status Ports — UltraScale Architectures (Cont'd)

Signal Name	Direction	Clock Domain	Description
<b>RX Decision Feedback Equalizer (DFE)</b>			
gt_rxlpmen[1:0]	In	Async	RX datapath. 0: DFE. 1: LPM.
gt_rxdfelpmreset[1:0]	In	Async	Reset for LPM and DFE datapath.
<b>TX Driver</b>			
gt_txpostcursor[9:0]	In	Async	Transmitter post-cursor TX post-emphasis control.
gt_txprecursor[9:0]	In	Async	Transmitter post-cursor TX pre-emphasis control.
gt_txdiffctrl[7:0]	In	Async	Driver Swing Control. The bus size is 20 bits for GTYE3 and 16 bits for GTHE3.
gt_txinhibit[1:0]	In	clk156_out	When High, this signal blocks the transmission of data.
<b>PRBS</b>			
gt_rxprbscntreset[1:0]	In	clk156_out	Resets the PRBS error counter.
gt_rxprbserr[1:0]	Out	clk156_out	This non-sticky status output indicates that PRBS errors have occurred.
gt_rxprbssel[7:0]	In	clk156_out	Receiver PRBS checker test pattern control.
gt_txprbssel[7:0]	In	clk156_out	Transmitter PRBS generator test pattern control.
gt_txprbsforceerr[1:0]	In	clk156_out	When this port is driven High, errors are forced in the PRBS transmitter. While this port is asserted, the output data pattern contains errors.
<b>RX CDR</b>			
gt_rxcdrhold[1:0]	In	Async	Hold the CDR control loop frozen.
<b>Digital Monitor</b>			
gt_dmonitorout[33:0]	Out	Async	Digital Monitor Output Bus
<b>Status</b>			
gt_rxdisperr[7:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data has a disparity error.
gt_rxnotintable[7:0]	Out	clk156_out	Active-High indicates the corresponding byte of the received data was not a valid character in the 8B/10B table.
gt_rxcommadet[1:0]	Out	clk156_out	This signal is asserted when the comma alignment block detects a comma.

**Notes:**

1. If you are migrating from a 7 series to an UltraScale device, the prefixes of the optional transceiver debug ports for single-lane cores are changed from "gt0", "gt1" to "gt", and the suffix "\_in" and "\_out" are dropped. For multi-lane cores, the prefixes of the optional transceiver debug ports gt(n) are aggregated into a single port. See [Device Migration](#) for more information

## Debug Interface

A debug port is provided that contains easy access to some of the important core signals.

Table 2-15: Debug Ports

Signal Name	Direction	Clock Domain	Description
debug	Out	clk156_out	Debug Port Bit[5] = Align Status Bits[4:1] = Sync Status Bit[0] = TX Phase Align Complete

## Alignment and Synchronization Status Ports

In addition to the configuration and status interfaces described in the previous section, there is some information on the debug output port signaling the alignment and synchronization status of the receiver (Table 2-16).

Table 2-16: Alignment Status and Synchronization Status Ports

Port Name	Description
debug[5]	1 when the RXAUI receiver is aligned across all four XAUI logical lanes, 0 otherwise.
debug[4:1]	Each pin is 1 when the respective XAUI logical lane receiver is synchronized to byte boundaries, 0 otherwise.

## Register Space

This section describes the interfaces available for dynamically setting the configuration and obtaining the status of the RXAUI core. There are two interfaces for configuration; depending on the core customization, only one is available in a particular core instance. The interfaces are:

- [MDIO Interface Registers](#)
- [Configuration and Status Vectors](#)

In addition, there are output ports on the core signaling alignment and synchronization status. These ports are described in [Alignment and Synchronization Status Ports](#).

## MDIO Interface Registers

For a description of the MDIO Interface, see [MDIO Interface](#).

### 10GBASE-X PCS/PMA Register Map

When the core is configured as a 10GBASE-X PCS/PMA, it occupies MDIO Device Addresses 1 and 3 in the MDIO register address map, as shown in [Table 2-17](#).

Table 2-17: 10GBASE-X PCS/PMA MDIO Registers

Register Address	Register Name
1.0	PMA/PMD Control 1
1.1	PMA/PMD Status 1
1.2,1.3	PMA/PMD Device Identifier
1.4	PMA/PMD Speed Ability
1.5, 1.6	PMA/PMD Devices in Package
1.7	10G PMA/PMD Control 2
1.8	10G PMA/PMD Status 2
1.9	Reserved
1.10	10G PMD Receive Signal OK
1.11 TO 1.13	Reserved
1.14, 1.15	PMA/PMD Package Identifier
1.16 to 1.65 535	Reserved
3.0	PCS Control 1
3.1	PCS Status 1
3.2, 3.3	PCS Device Identifier
3.4	PCS Speed Ability
3.5, 3.6	PCS Devices in Package
3.7	10G PCS Control 2
3.8	10G PCS Status 2
3.9 to 3.13	Reserved
3.14, 3.15	Package Identifier
3.16 to 3.23	Reserved
3.24	10GBASE-X PCS Status
3.25	10GBASE-X Test Control
3.26 to 3.65 535	Reserved

### MDIO Register 1.0: PMA/PMD Control 1

Figure 2-1 shows the MDIO Register 1.0: PMA/PMD Control 1.

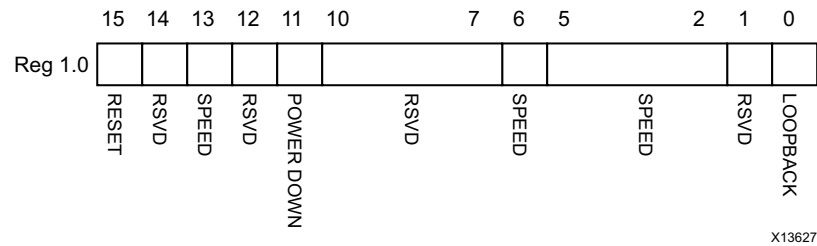


Figure 2-1: PMA/PMD Control 1 Register

Table 2-18 shows the PMA Control 1 register bit definitions.

Table 2-18: PMA/PMD Control 1 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.0.15	Reset	0	R/W Self-clearing	0 = Normal operation 1 = Block reset The RXAUI block is reset when this bit is set to 1. It returns to 0 when the reset is complete. The soft_reset pin is connected to this bit. This can be connected to the reset of any other MMDs.
1.0.14	Reserved	0	R	The block always returns 0 for this bit and ignores writes.
1.0.13	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
1.0.12	Reserved	0	R	The block always returns 0 for this bit and ignores writes.
1.0.11	Power-down	0	R/W	0 = Normal operation 1 = Power-down mode When set to 1, the serial transceivers are placed in a low power state. Set to 0 to return to normal operation
1.0.10:7	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
1.0.6	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
1.0.5:2	Speed Selection	All 0s	R	The block always returns 0s for these bits and ignores writes.
1.0.1	Reserved	All 0s	R	The block always returns 0 for this bit and ignores writes
1.0.0	Loopback	0	R/W	0 = Disable loopback mode 1 = Enable loopback mode The RXAUI block loops the signal in the serial transceivers back into the receiver. Near-end PMA loopback is always used.



**MDIO Register 1.1: PMA/PMD Status 1**

Figure 2-2 shows the MDIO Register 1.1: PMA/PMD Status 1.

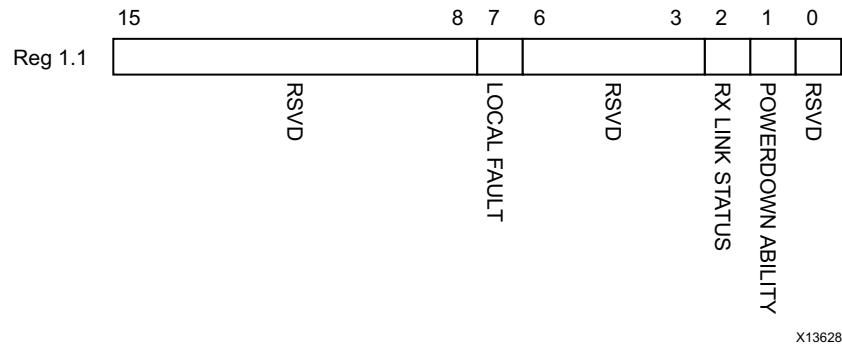


Figure 2-2: PMA/PMD Status 1 Register

Table 2-19 shows the PMA/PMD Status 1 register bit definitions.

Table 2-19: PMA/PMD Status 1 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.1.15:8	Reserved	0	R	The block always returns 0 for this bit.
1.1.7	Local Fault	0	R	The block always returns 0 for this bit.
1.1.6:3	Reserved	0	R	The block always returns 0 for this bit.
1.1.2	Receive Link Status	1	R	The block always returns 1 for this bit.
1.1.1	Power-down Ability	1	R	The block always returns 1 for this bit.
1.1.0	Reserved	0	R	The block always returns 0 for this bit.

**MDIO Registers 1.2 and 1.3: PMA/PMD Device Identifier**

Figure 2-3 shows the MDIO Registers 1.2 and 1.3: PMA/PMD Device Identifier.

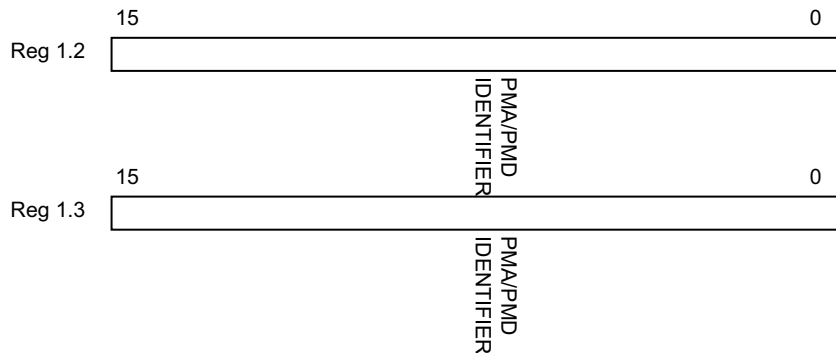


Figure 2-3: PMA/PMD Device Identifier Registers

Table 2-20 shows the PMA/PMD Device Identifier registers bit definitions.

Table 2-20: PMA/PMD Device Identifier Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.2.15:0	PMA/PMD Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.
1.3.15:0	PMA/PMD Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.

**MDIO Register 1.4: PMA/PMD Speed Ability**

Figure 2-4 shows the MDIO Register 1.4: PMA/PMD Speed Ability.

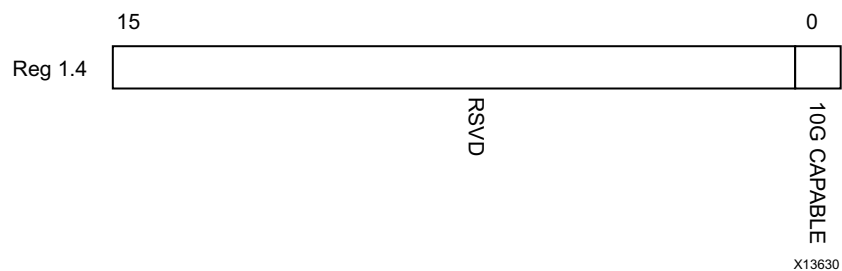


Figure 2-4: PMA/PMD Speed Ability Register

Table 2-21 shows the PMA/PMD Speed Ability register bit definitions.

Table 2-21: PMA/PMD Speed Ability Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.4.15:1	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
1.4.0	10G Capable	1	R	The block always returns 1 for this bit and ignores writes.

**MDIO Registers 1.5 and 1.6: PMA/PMD Devices in Package**

Figure 2-5 shows the MDIO Registers 1.5 and 1.6: PMA/PMD Devices in Package.

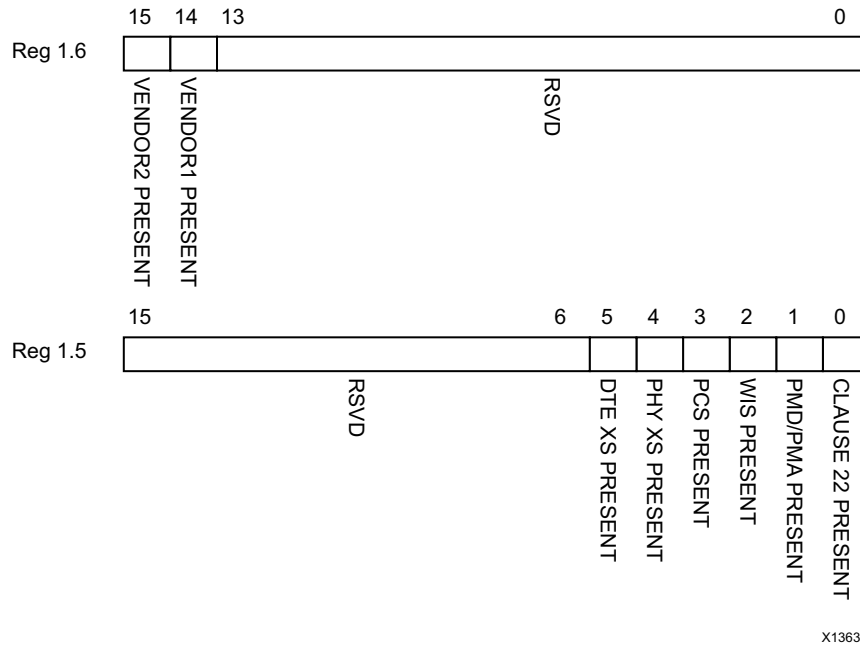


Figure 2-5: PMA/PMD Devices in Package Registers

Table 2-22 shows the PMA/PMD Device in Package registers bit definitions.

Table 2-22: PMA/PMD Devices in Package Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.6.15	Vendor- specific Device 2 present	0	R	The block always returns 0 for this bit.
1.6.14	Vendor-specific Device 1 present	0	R	The block always returns 0 for this bit.
1.6.13:0	Reserved	All 0s	R	The block always returns 0 for these bits.
1.5.15:6	Reserved	All 0s	R	The block always returns 0 for these bits.
1.5.5	DTE XS present	0	R	The block always returns 0 for this bit.
1.5.4	PHY XS present	0	R	The block always returns 0 for this bit.
1.5.3	PCS present	1	R	The block always returns 1 for this bit.
1.5.2	WIS present	0	R	The block always returns 0 for this bit.
1.5.1	PMA/PMD present	1	R	The block always returns 1 for this bit.
1.5.0	Clause 22 Device present	0	R	The block always returns 0 for this bit.

**MDIO Register 1.7: 10G PMA/PMD Control 2**

Figure 2-6 shows the MDIO Register 1.7: 10G PMA/PMD Control 2.

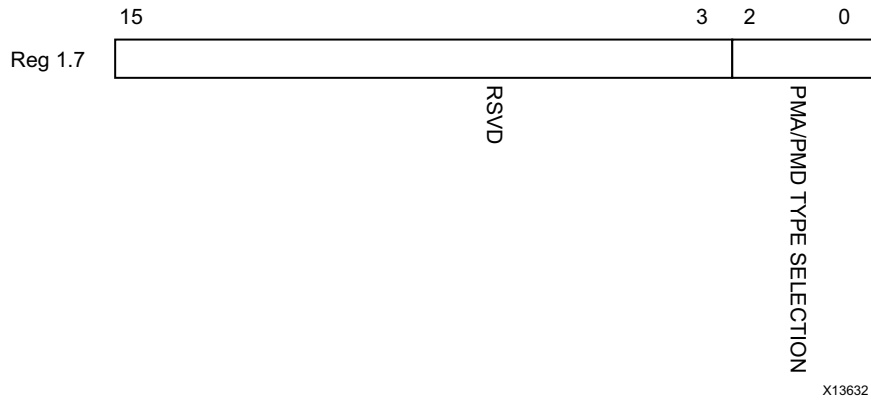


Figure 2-6: 10G PMA/PMD Control 2 Register

Table 2-23 shows the PMA/PMD Control 2 register bit definitions.

Table 2-23: 10G PMA/PMD Control 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.7.15:3	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
1.7.2:0	PMA/PMD Type Selection	100	R	The block always returns 100 for these bits and ignores writes. This corresponds to the 10GBASE-X PMA/PMD.

**MDIO Register 1.8: 10G PMA/PMD Status 2**

Figure 2-7 shows the MDIO Register 1.8: 10G PMA/PMD Status 2.

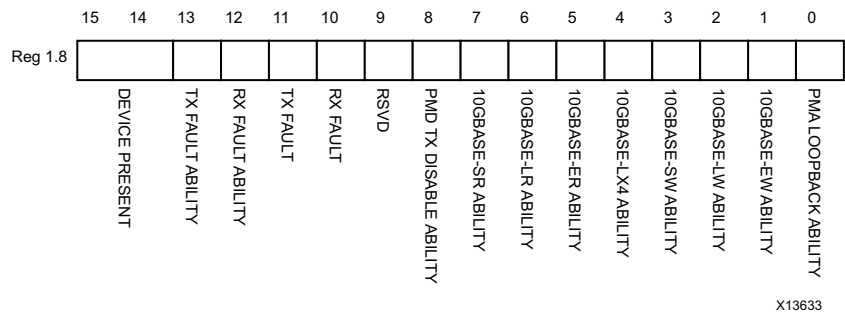


Figure 2-7: 10G PMA/PMD Status 2 Register

Table 2-24 shows the PMA/PMD Status 2 register bit definitions.

Table 2-24: 10G PMA/PMD Status 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.8.15:14	Device present	10	R	The block always returns 10 for these bits.
1.8.13	Transmit Local Fault Ability	0	R	The block always returns 0 for this bit.
1.8.12	Receive Local Fault Ability	0	R	The block always returns 0 for this bit.
1.8.11	Transmit Fault	0	R	The block always returns 0 for this bit.
1.8.10	Receive Fault	0	R	The block always returns 0 for this bit.
1.8.9	Reserved	0	R	The block always returns 0 for this bit.
1.8.8	PMD Transmit Disable Ability	0	R	The block always returns 0 for this bit.
1.8.7	10GBASE-SR Ability	0	R	The block always returns 0 for this bit.
1.8.6	10GBASE-LR Ability	0	R	The block always returns 0 for this bit.
1.8.5	10GBASE-ER Ability	0	R	The block always returns 0 for this bit.
1.8.4	10GBASE-LX4 Ability	1	R	The block always returns 1 for this bit.
1.8.3	10GBASE-SW Ability	0	R	The block always returns 0 for this bit.
1.8.2	10GBASE-LW Ability	0	R	The block always returns 0 for this bit.
1.8.1	10GBASE-EW Ability	0	R	The block always returns 0 for this bit.
1.8.0	PMA Loopback Ability	1	R	The block always returns 1 for this bit.

**MDIO Register 1.10: 10G PMD Signal Receive OK**

Figure 2-8 shows the MDIO 1.10 Register: 10G PMD Signal Receive OK.

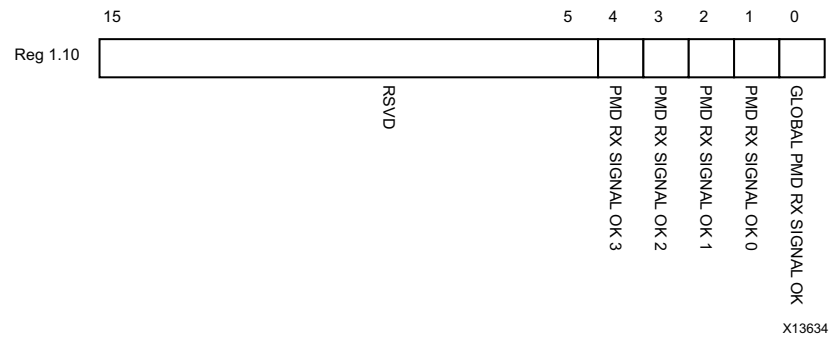


Figure 2-8: 10G PMD Signal Receive OK Register

Table 2-25 shows the 10G PMD Signal Receive OK register bit definitions.

Table 2-25: 10G PMD Signal Receive OK Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.10.15:5	Reserved	All 0s	R	The block always returns 0s for these bits.
1.10.4	PMD Receive Signal OK 3	–	R	0 = Signal not OK on receive Lane 3 1 = Signal OK on receive Lane 3 This is the value of the SIGNAL_DETECT[1] port.
1.10.3	PMD Receive Signal OK 2	–	R	0 = Signal not OK on receive Lane 2 1 = Signal OK on receive Lane 2 This is the value of the SIGNAL_DETECT[1] port.
1.10.2	PMD Receive Signal OK 1	–	R	0 = Signal not OK on receive Lane 1 1 = Signal OK on receive Lane 1 This is the value of the SIGNAL_DETECT[0] port.
1.10.1	PMD Receive Signal OK 0	–	R	0 = Signal not OK on receive Lane 0 1 = Signal OK on receive Lane 0 This is the value of the SIGNAL_DETECT[0] port.
1.10.0	Global PMD Receive Signal OK	–	R	0 = Signal not OK on all receive lanes 1 = Signal OK on all receive lanes

**MDIO Registers 1.14 and 1.15: PMA/PMD Package Identifier**

Figure 2-9 shows the MDIO Registers 1.14 and 1.15: PMA/PMD Package Identifier register.

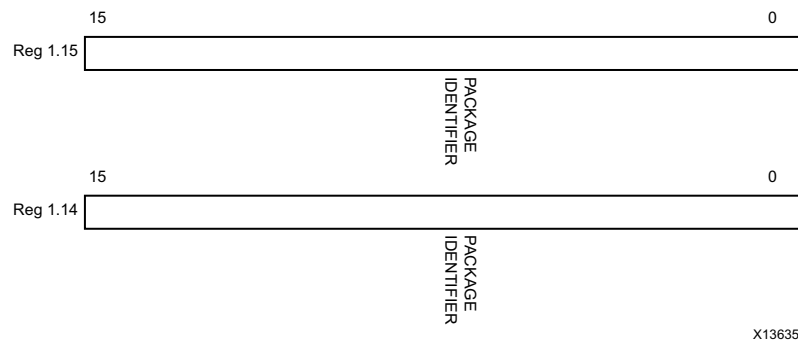


Figure 2-9: PMA/PMD Package Identifier Registers

Table 2-26 shows the PMA/PMD Package Identifier registers bit definitions.

Table 2-26: PMA/PMD Package Identifier Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
1.15.15:0	PMA/PMD Package Identifier	All 0s	R	The block always returns 0 for these bits.
1.14.15:0	PMA/PMD Package Identifier	All 0s	R	The block always returns 0 for these bits.

### MDIO Register 3.0: PCS Control 1

Figure 2-10 shows the MDIO Register 3.0: PCS Control 1.

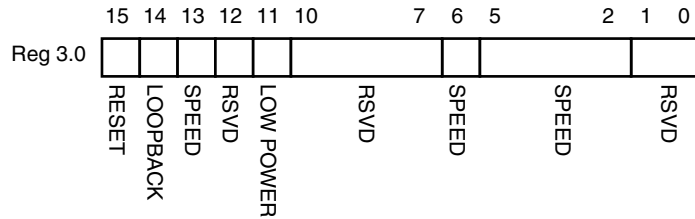


Figure 2-10: PCS Control 1 Register

Table 2-27 shows the PCS Control 1 register bit definitions.

Table 2-27: PCS Control 1 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.0.15	Reset	0	R/W Self-clearing	0 = Normal operation 1 = Block reset The RXAUI block is reset when this bit is set to 1. It returns to 0 when the reset is complete.
3.0.14	10GBASE-R Loopback	0	R	The block always returns 0 for this bit and ignores writes.
3.0.13	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
3.0.12	Reserved	0	R	The block always returns 0 for this bit and ignores writes.
3.0.11	Power-down	0	R/W	0 = Normal operation 1 = Power-down mode When set to 1, the serial transceivers are placed in a low power state. Set to 0 to return to normal operation.
3.0.10:7	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
3.0.6	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
3.0.5:2	Speed Selection	All 0s	R	The block always returns 0s for these bits and ignores writes.
3.0.1:0	Reserved	All 0s	R	The block always returns 0 for this bit and ignores writes.

**MDIO Register 3.1: PCS Status 1**

Figure 2-11 shows the MDIO Register 3.1: PCS Status 1.

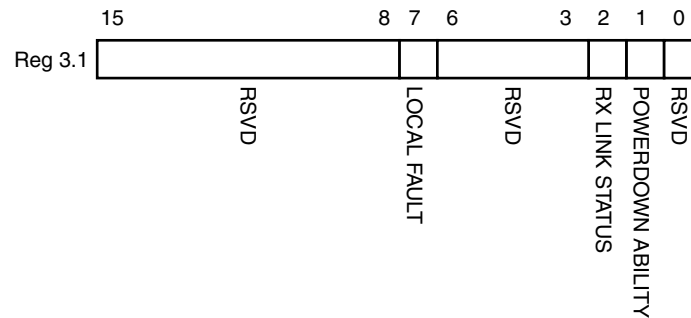


Figure 2-11: PCS Status 1 Register

Table 2-28 show the PCS 1 register bit definitions.

Table 2-28: PCS Status 1 Register Bit Definition

Bits	Name	Reset Value	Access Type	Description
3.1.15:8	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
3.1.7	Local Fault	–	R	0 = No local fault detected 1 = Local fault detected This bit is set to 1 whenever either of the bits 3.8.11 and 3.8.10 are set to 1.
3.1.6:3	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
3.1.2	PCS Receive Link Status	–	R Self-setting	0 = The PCS receive link is down 1 = The PCS receive link is up This is a latching Low version of bit 3.24.12. Latches 0 if Link Status goes down. Clears to current Link Status on read.
3.1.1	Power-down Ability	1	R	The block always returns 1 for this bit.
3.1.0	Reserved	0	R	The block always returns 0 for this bit and ignores writes.



**MDIO Registers 3.2 and 3.3: PCS Device Identifier**

Figure 2-12 shows the MDIO Registers 3.2 and 3.3: PCS Device Identifier.

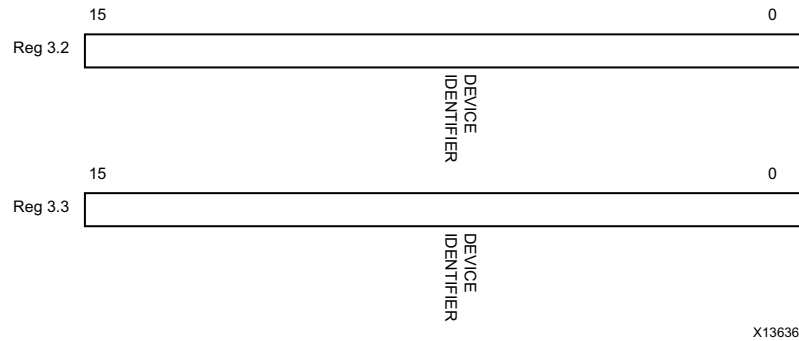


Figure 2-12: PCS Device Identifier Registers

Table 2-29 shows the PCS Device Identifier registers bit definitions.

Table 2-29: PCS Device Identifier Registers Bit Definition

Bits	Name	Reset Value	Access Type	Description
3.2.15:0	PCS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.
3.3.15:0	PCS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.

**MDIO Register 3.4: PCS Speed Ability**

Figure 2-13 shows the MDIO Register 3.4: PCS Speed Ability.

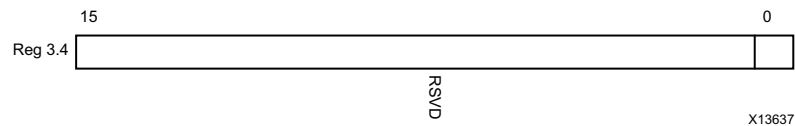


Figure 2-13: PCS Speed Ability Register

Table 2-30 shows the PCS Speed Ability register bit definitions.

Table 2-30: PCS Speed Ability Register Bit Definition

Bits	Name	Reset Value	Access Type	Description
3.4.15:1	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
3.4.0	10G Capable	1	R	The block always returns 1 for this bit and ignores writes.

### MDIO Registers 3.5 and 3.6: PCS Devices in Package

Figure 2-14 shows the MDIO Registers 3.5 and 3.6: PCS Devices in Package.

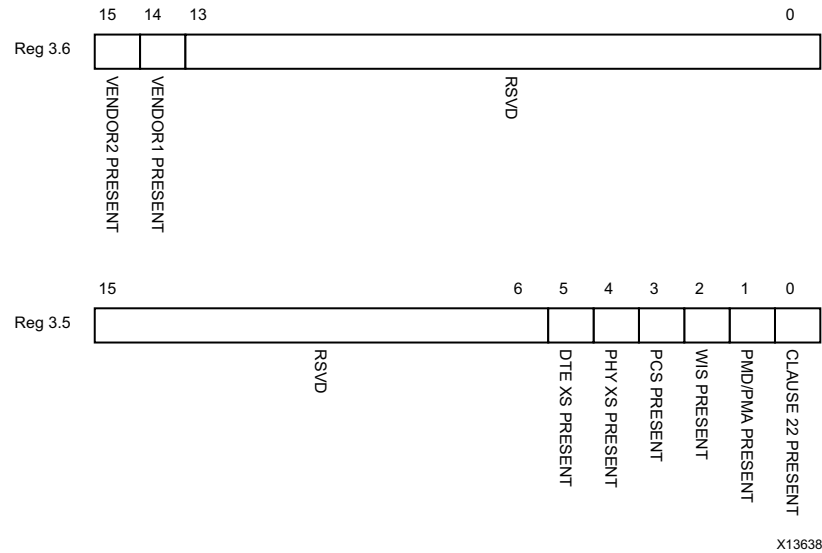


Figure 2-14: PCS Devices in Package Registers

Table 2-31 shows the PCS Devices in Package registers bit definitions.

Table 2-31: PCS Devices in Package Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.6.15	Vendor-specific Device 2 present	0	R	The block always returns 0 for this bit.
3.6.14	Vendor- specific Device 1 present	0	R	The block always returns 0 for this bit.
3.6.13:0	Reserved	All 0s	R	The block always returns 0 for these bits.
3.5.15:6	Reserved	All 0s	R	The block always returns 0 for these bits.
3.5.5	PHY XS present	0	R	The block always returns 0 for this bit.
3.5.4	PHY XS present	0	R	The block always returns 0 for this bit.
3.5.3	PCS present	1	R	The block always returns 1 for this bit.
3.5.2	WIS present	0	R	The block always returns 0 for this bit.
3.5.1	PMA/PMD present	1	R	The block always returns 1 for this bit.
3.5.0	Clause 22 device present	0	R	The block always returns 0 for this bit.

**MDIO Register 3.7: 10G PCS Control 2**

Figure 2-15 shows the MDIO Register 3.7: 10G PCS Control 2.

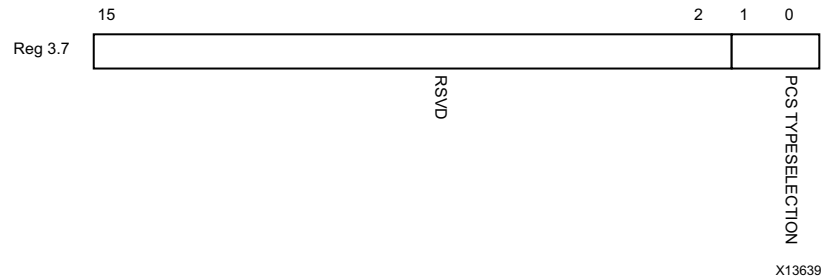


Figure 2-15: 10G PCS Control 2 Register

Table 2-32 shows the 10 G PCS Control 2 register bit definitions.

Table 2-32: 10G PCS Control 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.7.15:2	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
3.7.1:0	PCS Type Selection	01	R	The block always returns 01 for these bits and ignores writes.

**MDIO Register 3.8: 10G PCS Status 2**

Figure 2-16 shows the MDIO Register 3.8: 10G PCS Status 2.

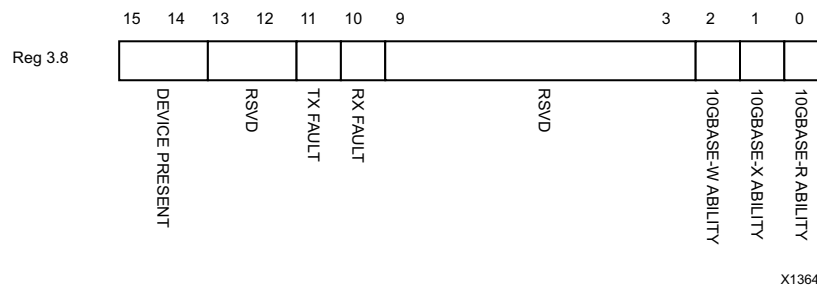


Figure 2-16: 10G PCS Status 2 Register

Table 2-33 shows the 10G PCS Status 2 register bit definitions.

Table 2-33: 10G PCS Status 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.8.15:14	Device present	10	R	The block always returns 10.
3.8.13:12	Reserved	All 0s	R	The block always returns 0 for these bits.

Table 2-33: 10G PCS Status 2 Register Bit Definitions (Cont'd)

Bits	Name	Reset Value	Access Type	Description
3.8.11	Transmit local fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on transmit path 1 = Fault condition on transmit path
3.8.10	Receive local fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on receive path 1 = Fault condition on receive path
3.8.9:3	Reserved	All 0s	R	The block always returns 0 for these bits.
3.8.2	10GBASE-W Capable	0	R	The block always returns 0 for this bit.
3.8.1	10GBASE-X Capable	1	R	The block always returns 1 for this bit.
3.8.0	10GBASE-R Capable	0	R	The block always returns 0 for this bit.

**MDIO Registers 3.14 and 3.15: PCS Package Identifier**

Figure 2-17 shows the MDIO Registers 3.14 and 3.15: PCS Package Identifier.

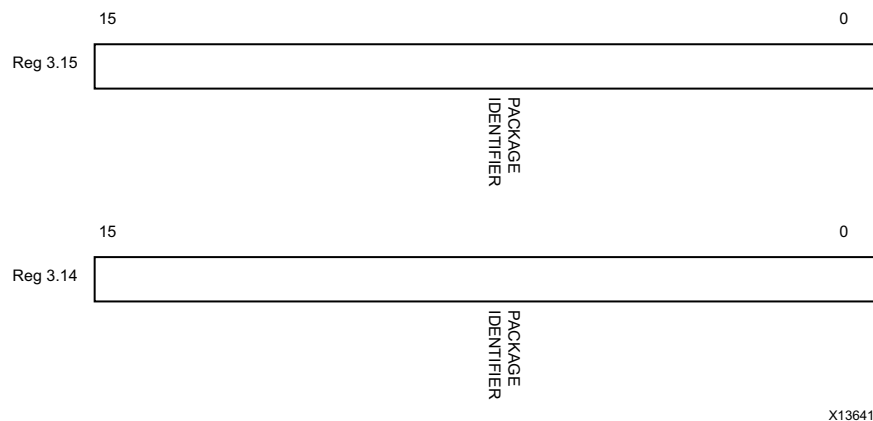


Figure 2-17: Package Identifier Registers

Table 2-34 shows the PCS Package Identifier registers bit definitions.

Table 2-34: PCS Package Identifier Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.14.15:0	Package Identifier	All 0s	R	The block always returns 0 for these bits.
3.15.15:0	Package Identifier	All 0s	R	The block always returns 0 for these bits.

**MDIO Register 3.24: 10GBASE-X Status**

Figure 2-18 shows the MDIO Register 3.24: 10GBase-X Status.

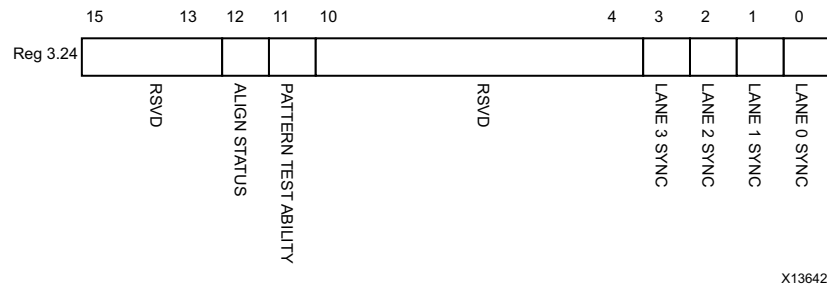


Figure 2-18: 10GBASE-X Status Register

Table 2-35 shows the 10GBase-X Status register bit definitions.

Table 2-35: 10GBASE-X Status Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.24.15:13	Reserved	All 0s	R	The block always returns 0 for these bits.
3.24.12	10GBASE-X Lane Alignment Status	–	R	0 = 10GBASE-X receive lanes not aligned 1 = 10GBASE-X receive lanes aligned
3.24.11	Pattern Testing Ability	1	R	The block always returns 1 for this bit.
3.24.10:4	Reserved	All 0s	R	The block always returns 0 for these bits.
3.24.3	Lane 3 Sync	–	R	0 = Lane 3 is not synchronized 1 = Lane 3 is synchronized
3.24.2	Lane 2 Sync	–	R	0 = Lane 2 is not synchronized 1 = Lane 2 is synchronized
3.24.1	Lane 1 Sync	–	R	0 = Lane 1 is not synchronized 1 = Lane 1 is synchronize
3.24.0	Lane 0 Sync	–	R	0 = Lane 0 is not synchronized 1 = Lane 0 is synchronized

**MDIO Register 3.25: 10GBASE-X Test Control**

Figure 2-19 shows the MDIO Register 3.25: 10GBase-X Test Control.

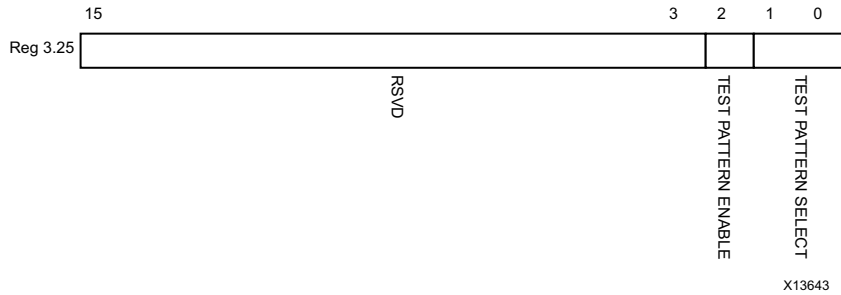


Figure 2-19: Test Control Register

Table 2-36 shows the 10GBase-X Test Control register bit definitions.

Table 2-36: 10GBASE-X Test Control Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
3.25.15:3	Reserved	All 0s	R	The block always returns 0 for these bits.
3.25.2	Transmit Test Pattern Enable	0	R/W	0 = Transmit test pattern disabled 1 = Transmit test pattern enable
3.25.1:0	Test Pattern Select	00	R/W	00 = High frequency test pattern 01 = Low frequency test pattern 10 = Mixed frequency test pattern 11 = Reserved

**DTE XS MDIO Register Map**

When the core is configured as a DTE XGXS, it occupies MDIO Device Address 5 in the MDIO register address map (Table 2-37).

Table 2-37: DTE XS MDIO Registers

Register Address	Register Name
5.0	DTE XS Control 1
5.1	DTE XS Status 1
5.2, 5.3	DTE XS Device Identifier
5.4	DTE XS Speed Ability
5.5, 5.6	DTE XS Devices in Package
5.7	Reserved
5.8	DTE XS Status 2
5.9 to 5.13	Reserved
5.14, 5.15	DTE XS Package Identifier

Table 2-37: DTE XS MDIO Registers (Cont'd)

Register Address	Register Name
5.16 to 5.23	Reserved
5.24	10G DTE XGXS Lane Status
5.25	10G DTE XGXS Test Control

**MDIO Register 5.0:DTE XS Control 1**

Figure 2-20 shows the MDIO Register 5.0: DTE XS Control 1.

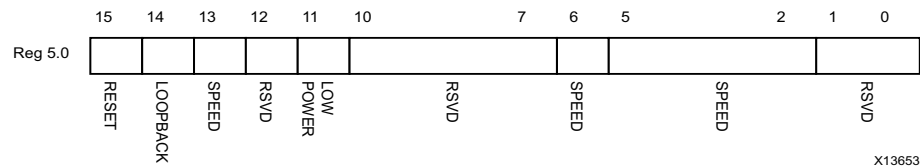


Figure 2-20: DTE XS Control 1 Register

Table 2-38 shows the DTE XS Control 1 register bit definitions.

Table 2-38: DTE XS Control 1 Register Bit Definitions

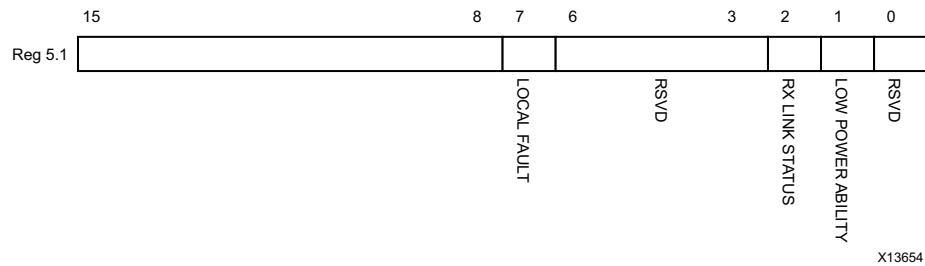
Bits	Name	Reset Value	Access Type	Description
5.0.15	Reset	0	R/W Self-clearing	0 = Normal operation 1 = Block reset The RXAUI block is reset when this bit is set to 1. It returns to 0 when the reset is complete.
5.0.14	Loopback	0	R/W	0 = Disable loopback mode 1 = Enable loopback mode The RXAUI block loops the signal in the serial transceivers back into the receiver.
5.0.13	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
5.0.12	Reserved	0	R	The block always returns 0 for this bit and ignores writes.
5.0.11	Power-down	0	R/W	0 = Normal operation 1 = Power-down mode When set to 1, the serial transceivers are placed in a low power state. Set to 0 to return to normal operation
5.0.10:7	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
5.0.6	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.

**Table 2-38: DTE XS Control 1 Register Bit Definitions (Cont'd)**

Bits	Name	Reset Value	Access Type	Description
5.0.5:2	Speed Selection	All 0s	R	The block always returns 0s for these bits and ignores writes.
5.0.1:0	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.

**MDIO Register 5.1: DTE XS Status 1**

Figure 2-21 shows the MDIO Register 5.1: DTE XS Status 1.



**Figure 2-21: DTE XS Status 1 Register**

Table 2-39 shows the DET XS Status 1 register bit definitions.

**Table 2-39: DTE XS Status 1 Register Bit Definitions**

Bits	Name	Reset Value	Access Type	Description
5.1.15:8	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
5.1.7	Local Fault	–	R	0 = No Local Fault detected 1 = Local fault detected This bit is set to 1 whenever either of the bits 5.8.11, 5.8.10 are set to 1.
5.1.6:3	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
5.1.2	DTE XS Receive Link Status	All 0s	R Self-setting	0 = The DTE XS receive link is down 1 = The DTE XS receive link is up This is a latching Low version of bit 5.24.12. Latches 0 if Link Status goes down. Clears to current Link Status on read.
5.1.1	Power-down Ability	1	R	The block always returns 1 for this bit.
5.1.0	Reserved	0	R	The block always returns 0 for this bit and ignores writes.



**MDIO Registers 5.2 and 5.3: DTE XS Device Identifier**

Figure 2-22 shows the MDIO Registers 5.2 and 5.3: DTE XS Device Identifier.

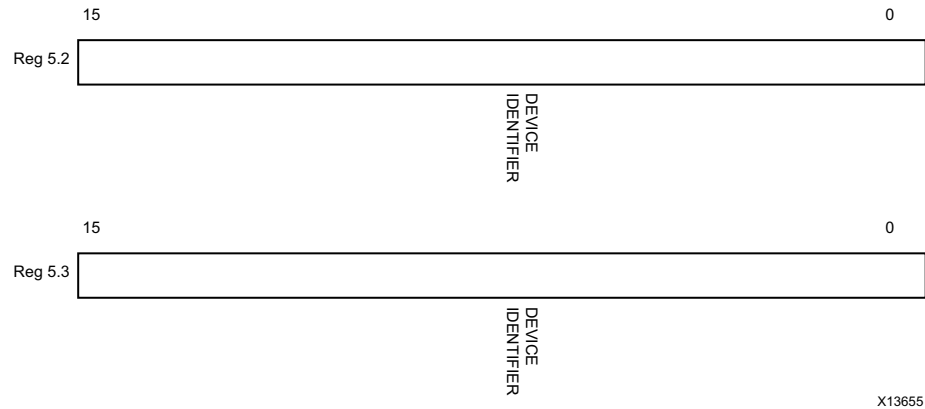


Figure 2-22: DTE XS Device Identifier Registers

Table 2-40 shows the DTE XS Device Identifier registers bit definitions.

Table 2-40: DTE XS Device Identifier Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.2.15:0	DTE XS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.
5.3.15:0	DTE XS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.

**MDIO Register 5.4: DTE XS Speed Ability**

Figure 2-23 shows the MDIO Register 5.4: DTE Speed Ability.

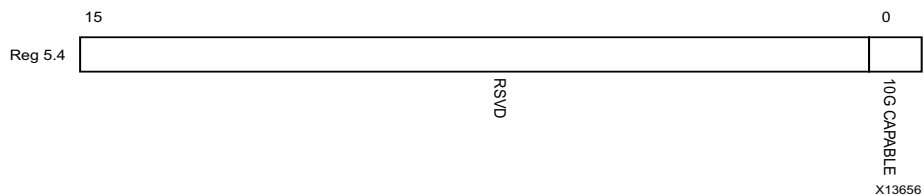


Figure 2-23: DTE XS Speed Ability Register

Table 2-41 shows the DTE XS Speed Ability register bit definitions.

Table 2-41: DTE XS Speed Ability Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.4.15:1	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
5.4.0	10G Capable	1	R	The block always returns 1 for this bit and ignores writes.

**MDIO Registers 5.5 and 5.6: DTE XS Devices in Package**

Figure 2-24 shows the MDIO Registers 5.5 and 5.6: DTE XS Devices in Package.

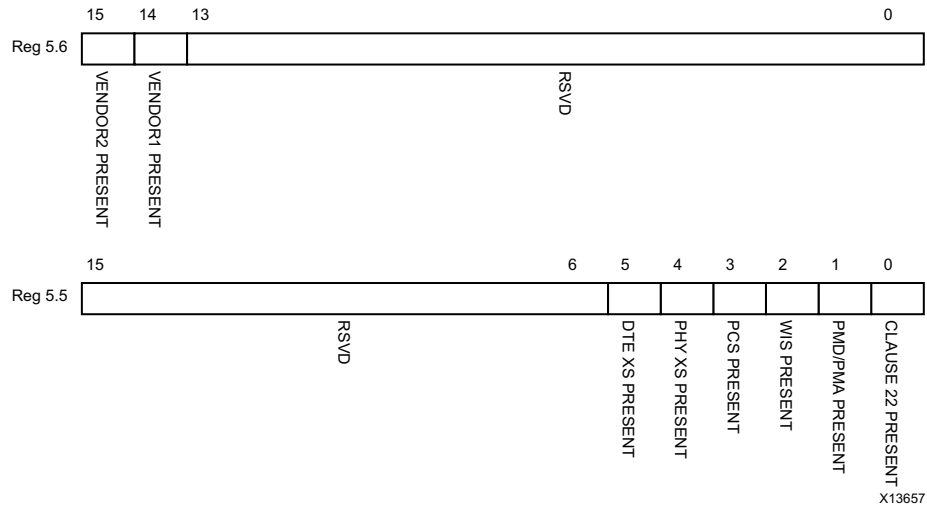


Figure 2-24: DTE XS Devices in Package Register

Table 2-42 shows the DTE XS Devices in Package registers bit definitions.

Table 2-42: DTE XS Devices in Package Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.6.15	Vendor-specific Device 2 present	0	R	The block always returns 0 for this bit.
5.6.14	Vendor-specific Device 1 present	0	R	The block always returns 0 for this bit.
5.6.13:0	Reserved	All 0s	R	The block always returns 0 for these bits.
5.6.15:6	Reserved	All 0s	R	The block always returns 0 for these bits.
5.5.5	DTE XS present	1	R	The block always returns 1 for this bit.
5.5.4	PHY XS present	0	R	The block always returns 0 for this bit.
5.5.3	PCS present	0	R	The block always returns 0 for this bit.
5.5.2	WIS present	0	R	The block always returns 0 for this bit.
5.5.1	PMA/PMD present	0	R	The block always returns 0 for this bit.
5.5.0	Clause 22 Device present	0	R	The block always returns 0 for this bit.

**MDIO Register 5.8: DTE XS Status 2**

Figure 2-25 shows the MDIO Register 5.8: DTE XS Status 2.

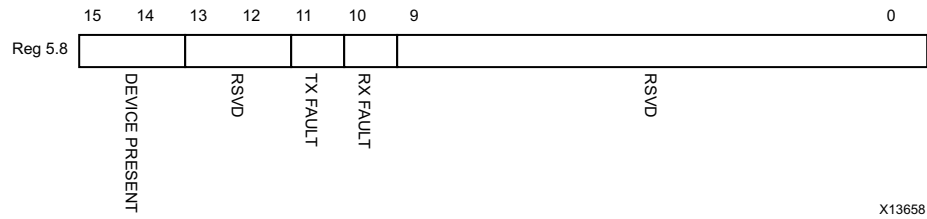


Figure 2-25: DTE XS Status 2 Register

Table 2-43 show the DTE XS Status 2 register bits definitions.

Table 2-43: DTE XS Status 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.8.15:14	Device present	10	R	The block always returns 10.
5.8.13:12	Reserved	All 0s	R	The block always returns 0 for these bits.
5.8.11	Transmit Local Fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on transmit path 1 = Fault condition on transmit path
5.8.10	Receive Local Fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on receive path 1 = Fault condition on receive path
5.8.9:0	Reserved	All 0s	R	The block always returns 0 for these bits.

**MDIO Registers 5.14 and 5.15: DTE XS Package Identifier**

Figure 2-26 shows the MDIO Registers 5.14 and 5.15: DTE XS Package Identifier.

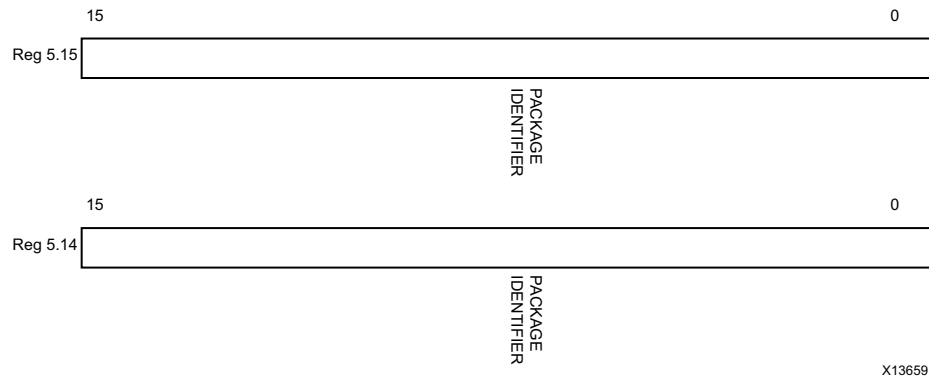


Figure 2-26: DTE XS Package Identifier Registers

Table 2-44 shows the DTE XS Package Identifier registers bit definitions.

Table 2-44: DTE XS Package Identifier Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.14.15:0	DTE XS Package Identifier	All 0s	R	The block always returns 0 for these bits.
5.15.15:0	DTE XS Package Identifier	All 0s	R	The block always returns 0 for these bits.

**Test Patterns**

The RXAUI core is capable of sending test patterns for system debug. These patterns are defined in Annex 48A of *IEEE Std. 802.3-2012* and transmission of these patterns is controlled by the MDIO Test Control Registers.

There are three types of pattern available:

- High frequency test pattern of 1010101010.... at each device-specific transceiver output
- Low frequency test pattern of 111110000011111000001111100000.... at each device-specific transceiver output
- mixed frequency test pattern of 111110101100000101001111101011000001010... at each device-specific transceiver output.

**MDIO Register 5.24: DTE XS Lane Status**

Figure 2-27 shows the MDIO Register 5.24: DTE XS Lane Status.

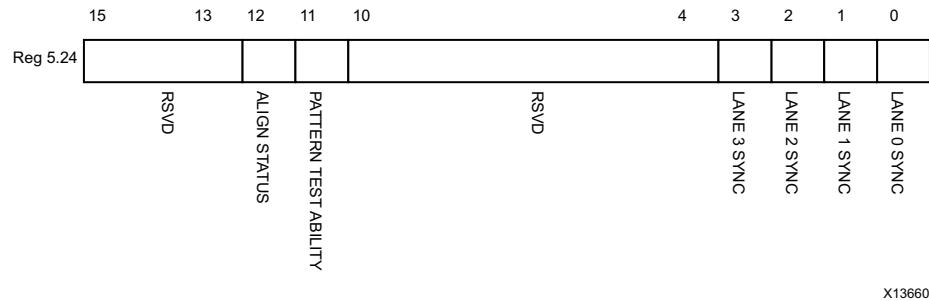


Figure 2-27: DTE XS Lane Status Register

Table 2-45 shows the DTE XS Lane Status register bit definitions.

Table 2-45: DTE XS Lane Status Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.24.15:13	Reserved	All 0s	R	The block always returns 0 for these bits.
5.24.12	DTE XGXS Lane Alignment Status	–	R	0 = DTE XGXS receive lanes not aligned 1 = DTE XGXS receive lanes aligned
5.24.11	Pattern testing ability	1	R	The block always returns 1 for this bit.
5.24.10:4	Reserved	All 0s	R	The block always returns 0 for these bits.
5.24.3	Lane 3 Sync	–	R	0 = Lane 3 is not synchronized 1 = Lane 3 is synchronized
5.24.2	Lane 2 Sync	–	R	0 = Lane 2 is not synchronized 1 = Lane 2 is synchronized
5.24.1	Lane 1 Sync	–	R	0 = Lane 1 is not synchronized 1 = Lane 1 is synchronized
5.24.0	Lane 0 Sync	–	R	0 = Lane 0 is not synchronized 1 = Lane 0 is synchronized

**MDIO Register 5.25: 10G DTE XGXS Test Control**

Figure 2-28 shows the MDIO Register 5.25: 10G DTE XGXS Test Control.

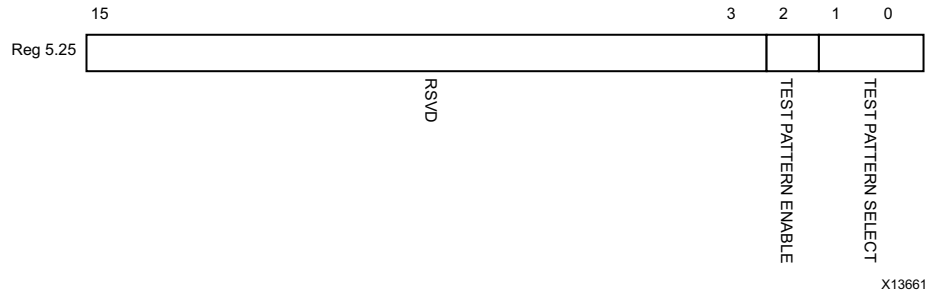


Figure 2-28: 10G DTE XGXS Test Control Register

Table 2-46 shows the 10G DTE XGXS Test Control register bit definitions.

Table 2-46: 10G DTE XGXS Test Control Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
5.25.15:3	Reserved	All 0s	R	The block always returns 0 for these bits.
5.25.2	Transmit Test Pattern Enable	0	R/W	0 = Transmit test pattern disabled 1 = Transmit test pattern enable
5.25.1:0	Test Pattern Select	00	R/W	00 = High frequency test pattern 01 = Low frequency test pattern 10 = Mixed frequency test pattern 11 = Reserved

**PHY XS MDIO Register Map**

When the core is configured as a PHY XGXS, it occupies MDIO Device Address 4 in the MDIO register address map (Table 2-47).

Table 2-47: PHY XS MDIO Registers

Register Address	Register Name
4.0	PHY XS Control 1
4.1	PHY XS Status 1
4.2, 4.3	Device Identifier
4.4	PHY XS Speed Ability
4.5, 4.6	Devices in Package
4.7	Reserved
4.8	PHY XS Status 2
4.9 to 4.13	Reserved
4.14, 4.15	Package Identifier

Table 2-47: PHY XS MDIO Registers (Cont'd)

Register Address	Register Name
4.16 to 4.23	Reserved
4.24	10G PHY XGXS Lane Status
4.25	10G PHY XGXS Test Control

**MDIO Register 4.0: PHY XS Control 1**

Figure 2-29 shows the MDIO Register 4.0: PHY XS Control 1.

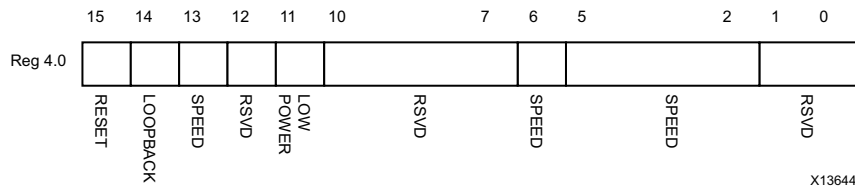


Figure 2-29: PHY XS Control 1 Register

Table 2-48 shows the PHY XS Control 1 register bit definitions.

Table 2-48: PHY XS Control 1 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.0.15	Reset	0	R/W Self-clearing	0 = Normal operation 1 = Block reset The RXAUI block is reset when this bit is set to 1. It returns to 0 when the reset is complete.
4.0.14	Loopback	0	R/W	0 = Disable loopback mode 1 = Enable loopback mode The RXAUI block loops the signal in the serial transceivers back into the receiver.
4.0.13	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
4.0.12	Reserved	0	R	The block always returns 0 for this bit and ignores writes.
4.0.11	Power-down	0	R/W	0 = Normal operation 1 = Power-down mode When set to 1, the serial transceivers are placed in a low power state. Set to 0 to return to normal operation
4.0.10:7	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
4.0.6	Speed Selection	1	R	The block always returns 1 for this bit and ignores writes.
4.0.5:2	Speed Selection	All 0s	R	The block always returns 0s for these bits and ignores writes.
4.0.1:0	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.

**MDIO Register 4.1: PHY XS Status 1**

Figure 2-30 shows the MDIO Register 4.1: PHY XS Status 1.

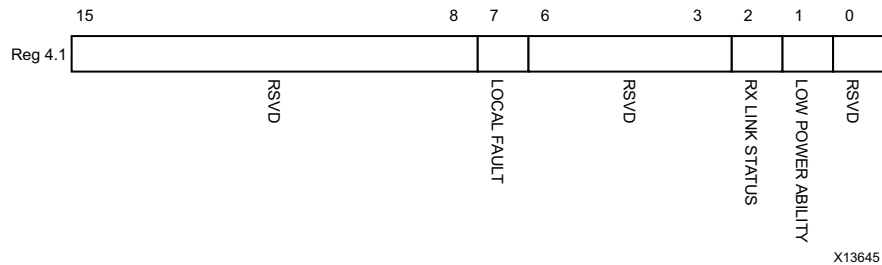


Figure 2-30: PHY XS Status 1 Register

Table 2-49 shows the PHY XS Status 1 register bit definitions.

Table 2-49: PHY XS Status 1 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.1.15:8	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
4.1.7	Local Fault	–	R	0 = No Local Fault detected 1 = Local fault detected This bit is set to 1 whenever either of the bits 4.8.11 and 4.8.10 are set to 1.
4.1.6:3	Reserved	All 0s	R	The block always returns 0s for these bits and ignores writes.
4.1.2	PHY XS Receive Link Status	–	R Self-setting	0 =The PHY XS receive link is down 1 = The PHY XS receive link is up. This is a latching Low version of bit 4.24.12. Latches 0 if Link Status goes down. Clears to current Link Status on read.
4.1.1	Power-down Ability	1	R	The block always returns 1 for this bit.
4.1.0	Reserved	0	R	The block always returns 0 for this bit and ignores writes.



**MDIO Registers 4.2 and 4.3: PHY XS Device Identifier**

Figure 2-31 shows the MDIO Registers 4.2 and 4.3: PHY XS Device Identifier.

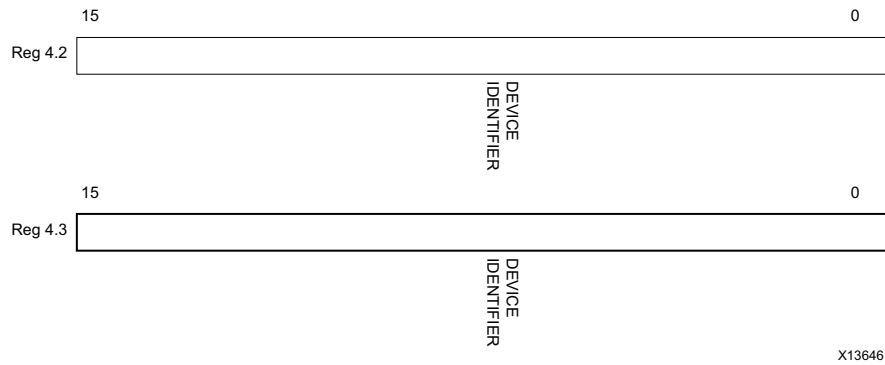


Figure 2-31: PHY XS Device Identifier Registers

Table 2-50 shows the PHY XS Devices Identifier registers bit definitions.

Table 2-50: PHY XS Device Identifier Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.2.15:0	PHY XS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.
4.3.15:0	PHY XS Identifier	All 0s	R	The block always returns 0 for these bits and ignores writes.

**MDIO Register 4.4: PHY XS Speed Ability**

Figure 2-32 shows the MDIO Register 4.4: PHY XS Speed Ability.

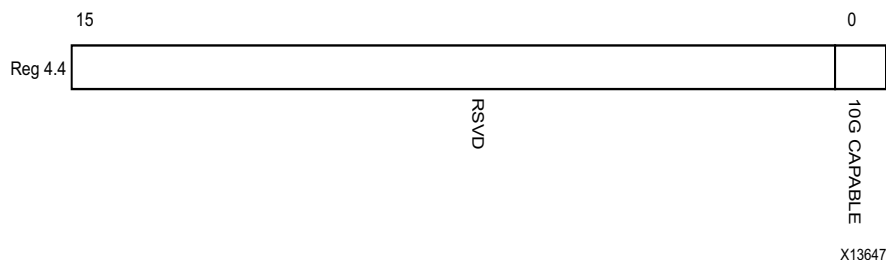


Figure 2-32: PHY XS Speed Ability Register

Table 2-51 shows the PHY XS Speed Ability register bit definitions.

Table 2-51: PHY XS Speed Ability Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.4.15:1	Reserved	All 0s	R	The block always returns 0 for these bits and ignores writes.
4.4.0	10G Capable	1	R	The block always returns 1 for this bit and ignores writes.

**MDIO Registers 4.5 and 4.6: PHY XS Devices in Package**

Figure 2-33 shows the MDIO Registers 4.5 and 4.6: PHY XS Devices in Package.

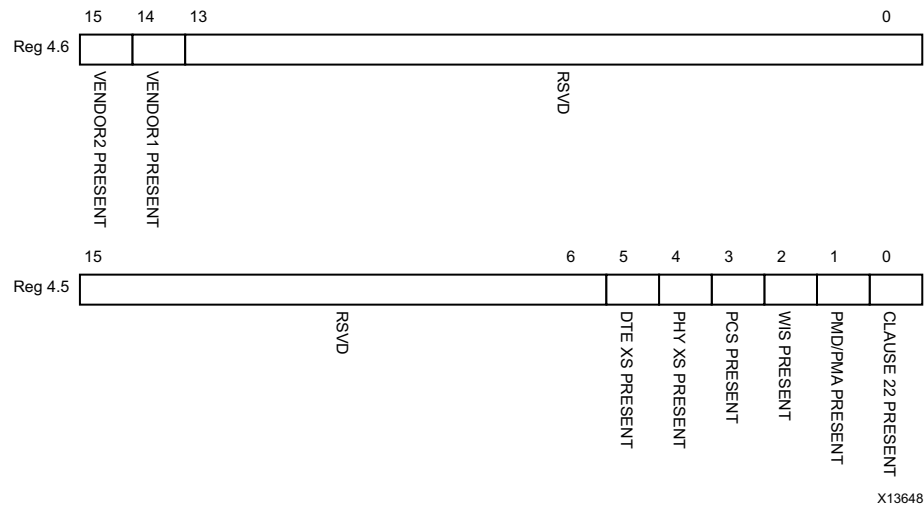


Figure 2-33: PHY XS Devices in Package Registers

Table 2-52 shows the PHY XS Devices in Package registers bit definitions.

Table 2-52: PHY XS Devices in Package Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.6.15	Vendor-specific Device 2 present	0	R	The block always returns 0 for this bit.
4.6.14	Vendor-specific Device 1 present	0	R	The block always returns 0 for this bit.
4.6.13:0	Reserved	All 0s	R	The block always returns 0 for these bits.
4.5.15:6	Reserved	All 0s	R	The block always returns 0 for these bits.
4.5.5	DTE XS present	0	R	The block always returns 0 for this bit.
4.5.4	PHY XS present	1	R	The block always returns 1 for this bit.
4.5.3	PCS present	0	R	The block always returns 0 for this bit.
4.5.2	WIS present	0	R	The block always returns 0 for this bit.
4.5.1	PMA/PMD present	0	R	The block always returns 0 for this bit.
4.5.0	Clause 22 device present	0	R	The block always returns 0 for this bit.

**MDIO Register 4.8: PHY XS Status 2**

Figure 2-34 shows the MDIO Register 4.8: PHY XS Status 2.

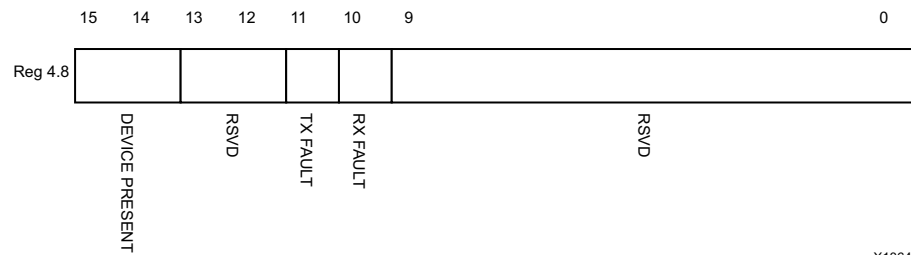


Figure 2-34: PHY XS Status 2 Register

Table 2-53 shows the PHY XS Status 2 register bit definitions.

Table 2-53: PHY XS Status 2 Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.8.15:14	Device present	10	R	The block always returns 10.
4.8.13:12	Reserved	All 0s	R	The block always returns 0 for these bits.
4.8.11	Transmit local fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on transmit path 1 = Fault condition on transmit path
4.8.10	Receive local fault	–	R Latching High. Automatically clears after a read unless the fault is present.	0 = No fault condition on receive path 1 = Fault condition on receive path
4.8.9:0	Reserved	All 0s	R	The block always returns 0 for these bits.

**MDIO Registers 4.14 and 4.15: PHY XS Package Identifier**

Figure 2-35 shows the MDIO 4.14 and 4.15 Registers: PHY XS Package Identifier.

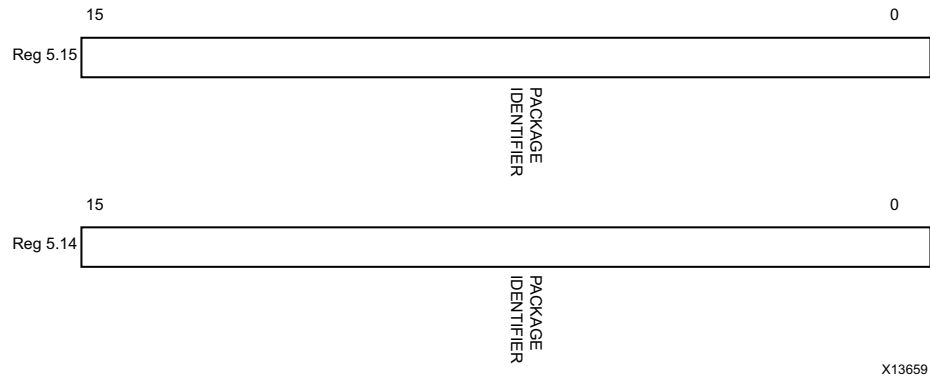


Figure 2-35: PHY XS Package Identifier Registers

Table 2-54 shows the Package Identifier registers bit definitions.

Table 2-54: Package Identifier Registers Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.15.15:0	PHY XS Package Identifier	All 0s	R	The block always returns 0 for these bits.
4.14.15:0	PHY XS Package Identifier	All 0s	R	The block always returns 0 for these bits.

**MDIO Register 4.24: 10G PHY XGXS Lane Status**

Figure 2-36 shows the MDIO Register 4.24: 10G XGXS Lane Status.

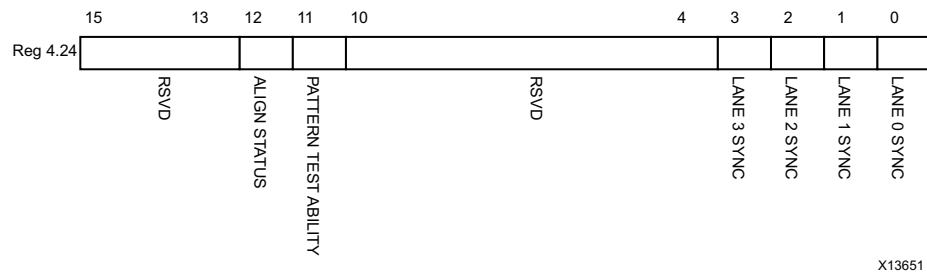


Figure 2-36: 10G PHY XGXS Lane Status Register

Table 2-55 shows the 10G PHY XGXS Lane register bit definitions.

Table 2-55: 10G PHY XGXS Lane Status Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.24.15:13	Reserved	All 0s	R	The block always returns 0 for these bits.
4.24.12	PHY XGXS Lane Alignment Status	–	R	0 = PHY XGXS receive lanes not aligned 1 = PHY XGXS receive lanes aligned
4.24.11	Pattern Testing Ability	1	R	The block always returns 1 for this bit.
4.24.10:4	Reserved	All 0s	R	The block always returns 0 for these bits.
4.24.3	Lane 3 Sync	–	R	0 = Lane 3 is not synchronized 1 = Lane 3 is synchronized
4.24.2	Lane 2 Sync	–	R	0 = Lane 2 is not synchronized 1 = Lane 2 is synchronized
4.24.1	Lane 1 Sync	–	R	0 = Lane 1 is not synchronized 1 = Lane 1 is synchronized
4.24.0	Lane 0 Sync	–	R	0 = Lane 0 is not synchronized 1 = Lane 0 is synchronized

**MDIO Register 4.25: 10G PHY XGXS Test Control**

Figure 2-37 shows the MDIO Register 4.25: 10G XGXS Test Control.

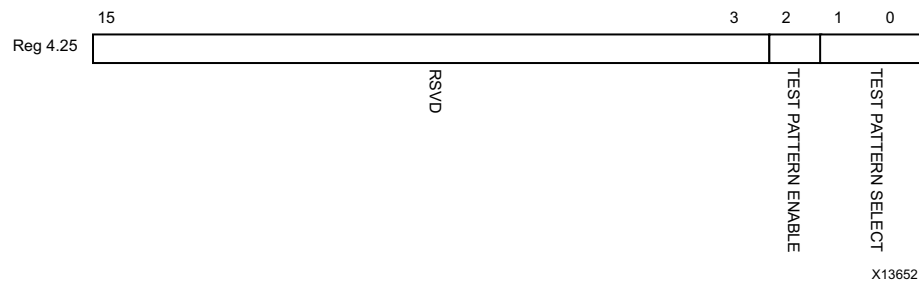


Figure 2-37: 10G PHY XGXS Test Control Register

Table 2-56 shows the 10G PHY XGXS Test Control register bit definitions.

Table 2-56: 10G PHY XGXS Test Control Register Bit Definitions

Bits	Name	Reset Value	Access Type	Description
4.25.15:3	Reserved	All 0s	R	The block always returns 0 for these bits.
4.25.2	Transmit Test Pattern Enable	0	R/W	0 = Transmit test pattern disabled 1 = Transmit test pattern enable
4.25.1:0	Test Pattern Select	00	R/W	00 = High frequency test pattern 01 = Low frequency test pattern 10 = Mixed frequency test pattern 11 = Reserved

## Configuration and Status Vectors

If the RXAUI core is generated without an MDIO interface, the key configuration and status information is carried on simple bit vectors, which are:

- configuration\_vector[6:0]
- status\_vector[7:0]

Table 2-57 shows the Configuration Vector bit definitions.

Table 2-57: Configuration Vector Bit Definitions

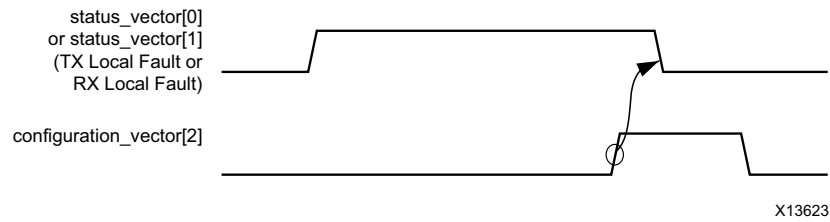
Bits	Name	Description
6:5	Test Select[1:0]	Selects the test pattern. See bits 5.25.1:0 in Table 2-46, page 46.
4	Test Enable	Enables transmit test pattern generation. See bit 5.25.2 in Table 2-46, page 46.
3	Reset RX Link Status	Sets the RX Link Status bit (status_vector[7]). See Table 2-58. This bit should be driven by a register on the same clock domain as the RXAUI core.
2	Reset Local Fault	Clears both TX Local Fault and RX Local Fault bits (status_vector[0] and status_vector[1]). See Table 2-58. This bit should be driven by a register on the same clock domain as the RXAUI core.
1	Power-down	Sets the device-specific transceivers into power-down mode. See bit 5.0.11 in Table 2-38, page 39.
0	Loopback	Sets serial loopback in the device-specific transceivers. See bit 5.0.14 in Table 2-38, page 39.

Table 2-58 shows the Status Vector bit definitions.

Table 2-58: Status Vector Bit Definitions

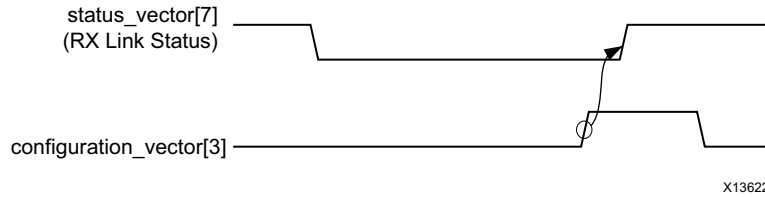
Bits	Name	Description
7	RX Link Status	1 if the Receiver link is up, otherwise 0. See bit 5.1.2 in Table 2-39, page 40. Latches Low. Cleared by rising edge on configuration_vector[3].
6	Alignment	1 if the RXAUI receiver is aligned over all four logical XAUI lanes, otherwise 0. See bit 5.24.12 in Table 2-44, page 44. This is also used to generate the align_status signal described in Table 2-16.
5:2	Synchronization	Each bit is 1 if the corresponding RXAUI lane is synchronized on receive, otherwise 0. See bits 5.24.3:0 in Table 2-44, page 44. These four bits are also used to generate the sync_status[3:0] signal described in Table 2-16.
1	RX Local Fault	1 if there is a fault in the receive path, otherwise 0. See bit 5.8.10 in Table 2-43, page 43. Latches High. Cleared by rising edge on configuration_vector[2].
0	TX Local Fault	1 if there is a fault in the transmit path, otherwise 0. See bit 5.8.11 in Table 2-43, page 43. Latches High. Cleared by rising edge on configuration_vector[2].

Bits[1:0] of the status\_vector port, the Local Fault bits, are latching-high and cleared low by Bit[2] of the configuration\_vector port. [Figure 2-38](#) shows how the status bits are cleared.



**Figure 2-38: Clearing the Local Fault Status Bits**

Bit[7] of the status\_vector port, the RX Link Status bit, is latching-low and set high by Bit[3] of the configuration vector. [Figure 2-39](#) shows how the status bit is set.



**Figure 2-39: Setting the RX Link Status Bit**

# Designing with the Core

This chapter includes guidelines and additional information to facilitate designing with the core.

---

## General Design Guidelines

This section describes the steps required to turn a RXAUI core into a fully-functioning design with user-application logic.



**IMPORTANT:** *Not all implementations require all of the design steps listed in this chapter. Follow the logic design guidelines in this manual carefully.*

---

## Use the Example Design as a Starting Point

The RXAUI core has an example design that can be implemented in an FPGA and simulated. This design can be used as a starting point for your own design or can be used to sanity-check your application in the event of difficulty.

See [Chapter 5, Example Design](#) for information about using and customizing the example designs for the RXAUI core.

## Know the Degree of Difficulty

RXAUI designs are challenging to implement in any technology, and the degree of difficulty is further influenced by:

- Maximum system clock frequency
- Targeted device architecture
- Nature of your application

All RXAUI implementations need careful attention to system performance requirements. Pipelining, logic mapping, placement constraints, and logic duplication are all methods that help boost system performance.



## Keep It Registered

To simplify timing and increase system performance in an FPGA design, keep all inputs and outputs registered between your application and the core. This means that all inputs and outputs from your application should come from, or connect to a flip-flop. While registering signals might not be possible for all paths, it simplifies timing analysis and makes it easier for the Xilinx<sup>®</sup> tools to place and route the design.

## Recognize Timing Critical Signals

The XDC provided with the example design for the core identifies the critical signals and the timing constraints that should be applied. See [Constraining the Core](#) for further information.

## Use Supported Design Flows

The core HDL is added to the open Vivado<sup>®</sup> project. The core is then synthesized along with the rest of the project as part of project synthesis.

## Make Only Allowed Modifications

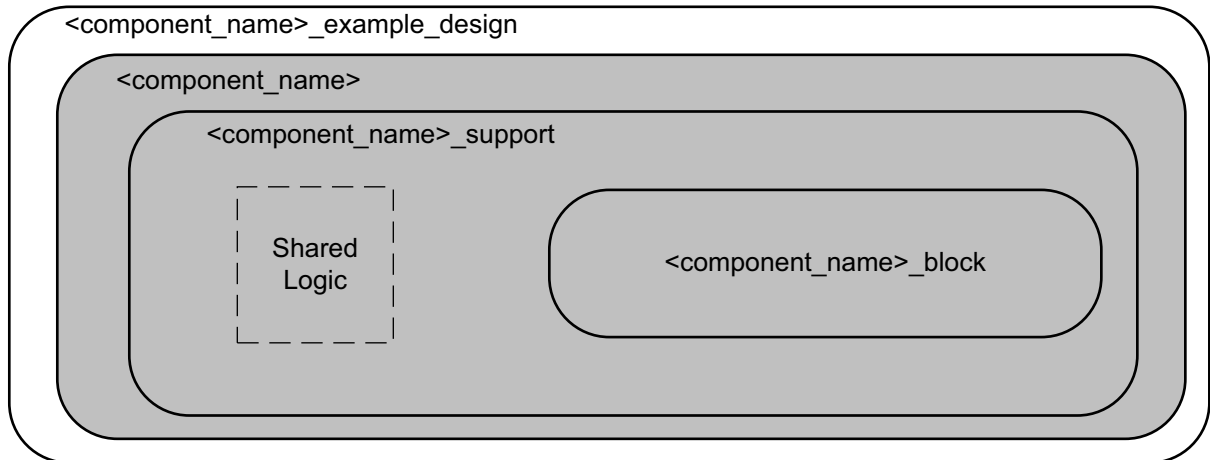
The RXAUI core is not user-modifiable. Do not make modifications as they can have adverse effects on system timing and protocol compliance. Supported user configurations of the RXAUI core can only be made by selecting the options from within the Vivado Design Suite tool when the core is generated. See [Customizing and Generating the Core](#).

---

## Shared Logic

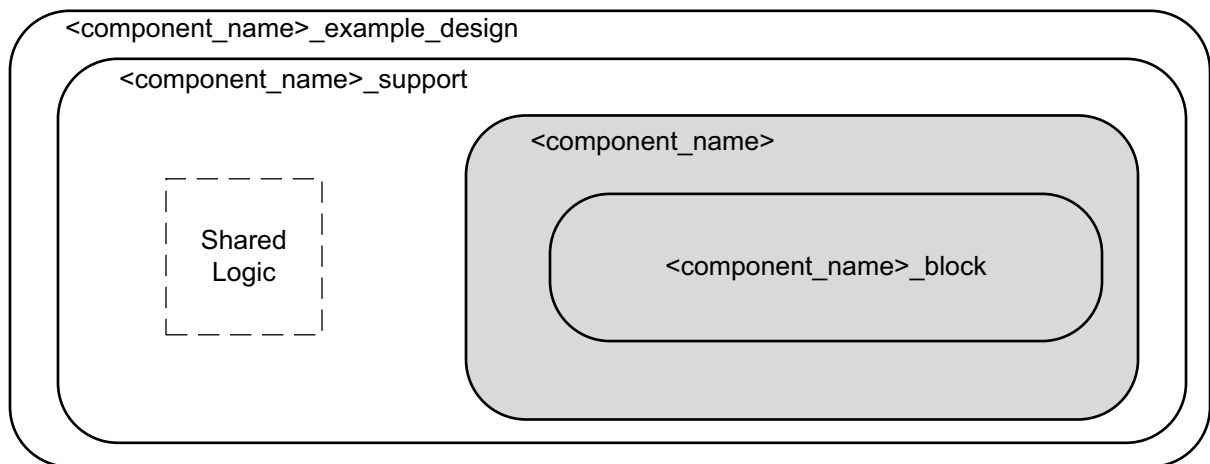
Shared Logic provides a flexible architecture that works both as a stand-alone core and as part of a larger design with one or more core instances. This minimizes the amount of HDL modifications required, but at the same time retains the flexibility for users of the core.

There is a level of hierarchy called `<component_name>_support`. [Figure 3-1](#) and [Figure 3-2](#) show two hierarchies where the shared logic is either contained in the core or in the example design. In these figures, `<component_name>` is the name of the generated core. The difference between the two hierarchies is the boundary of the core. It is controlled using the Shared Logic option in the RXAUI customization screen in the Vivado IDE.



X13670

Figure 3-1: Shared Logic Included in Core



X13671

Figure 3-2: Shared Logic Included in Example Design

The shared logic comprises IBUFDS\_GT, and the GT quad PLL with associated reset logic for 7 series, and IBUFDS\_GT and GT quad PLL for UltraScale architecture.

## Shared Logic in Core

Select this option if:

- You do not require direct control over the transceiver Quad PLL and transceiver differential clock buffer.
- You want to manage multiple customizations of the core for multi-core designs.
- This is the first RXAUI core in a multi-core system.

These components are included in the core, and their output ports are also provided as core outputs.

## Shared Logic in Example Design

Select this option if either:

- This is the second RXAUI core in a multi-core design
- You only want to manage one customization of the RXAUI core in your design
- You want direct access to the transceiver quad PLL and differential reference clock buffer.

To fully utilize a transceiver quad, customize one RXAUI core with shared logic in the core, and one with shared logic in the example design. You can connect the quad PLL outputs from the first RXAUI core to the second core.

If you want fine control - you can select 'Include shared logic in example design' and base your own logic on the shared logic produced in the example design.

## Clocking

The clocking schemes in this section are illustrative only and might require customization for a specific application. See [Table 2-5](#) for information on the clock ports.

The transceiver common PLL can be included as part of the core if the **Include Shared Logic in Core** option is selected in the Vivado IDE. If this option is deselected, it appears in the "support" layer in the example design for reference.

## Transceiver DRPCLK

A dedicated core input clock, `dc1k`, is connected to the DRPCLK port of the transceivers in the core for all devices. This clock frequency is flexible, allowing for the sharing of DRPCLK across all transceivers in a device.

The `dc1k` clock, provided to the core, must be a free running clock since it is also used to clock the logic for transceiver reset/initialization circuitry. The `dc1k` clock must not be derived from any transceiver output clocks.

For UltraScale devices only, the frequency of `dc1k` must be entered into the core customization screen prior to core generation; this frequency information is passed down to the UltraScale Transceiver Wizard contained within the RXAUI core, where it is used to generate correct timer durations for the transceiver reset/initialization circuitry.

## Transceiver Reference Clock

### *Zynq-7000 and 7 Series*

The transceivers require a differential reference clock of 156.25 MHz to operate at a line rate of 6.25 Gb/s.

### *UltraScale Architecture*

The reference clock frequency is selectable from the core customization screen. Available reference clock frequencies are:

- 125 MHz
- 156.25 MHz
- 312.5 MHz

### *Transceiver Placement*

A single IBUFDS\_GTE2 (7 series FPGAs) or a single IBUFDS\_GTE3 (UltraScale FPGA) is used to feed the reference clocks for both core transceivers, which must be in the same Quad. In addition, timing requirements are met if both transceivers are placed next to each other.

For details about transceiver clock distribution, see the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [Ref 2], *7 Series FPGAs GTP Transceivers User Guide* (UG482) [Ref 3], and the *UltraScale Architecture GTH Transceivers User Guide* (UG576) [Ref 4].

## Dune Networks RXAUI

The clocking scheme for the RXAUI core for each device transceiver type, with shared logic located either in the example design or in the core are shown in [Figure 3-3](#) through [Figure 3-12](#).

For all devices, a 156.25 MHz clock is derived from the transceiver TXOUTCLK port inside the core and used as the clock for the datapath logic of the RXAUI core. This clock should be used for user logic connecting to the core, using the `clk156_out` port; however, it cannot be used as a clock source for the user logic of a different RXAUI core because of problems with phase alignment.

Figure 3-3 shows the clocking scheme for 7 series and Zynq-7000 GTXE2 transceivers with Shared Logic included in the core.

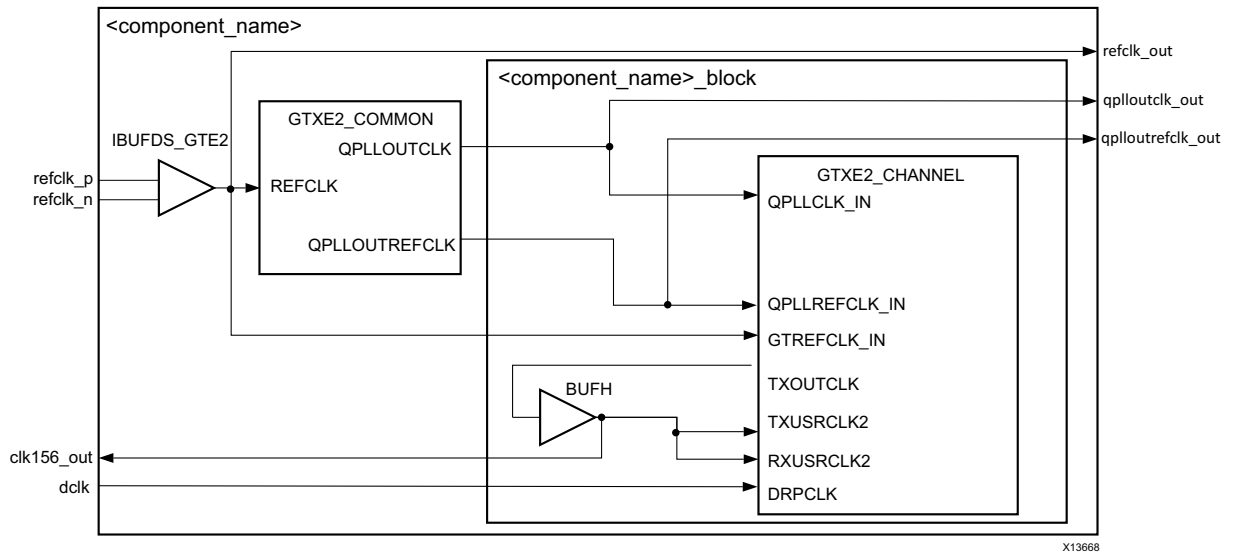


Figure 3-3: Clock Scheme for 7 Series GTXE2 Transceivers

Similarly, Figure 3-4 shows the clocking scheme for 7 series GTHE2 transceivers with Shared Logic included in the core.

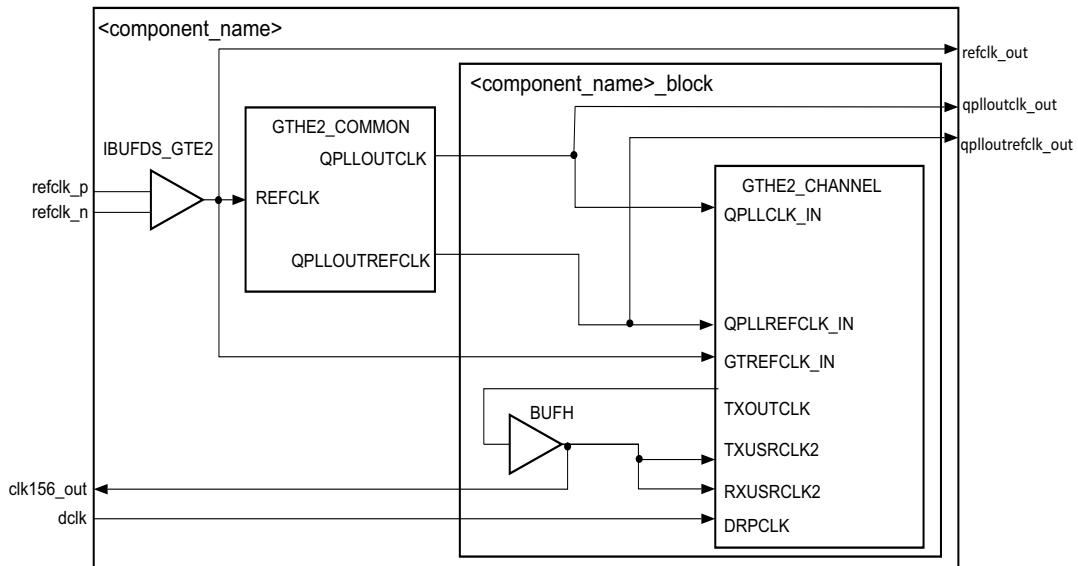


Figure 3-4: Clock Scheme for 7 Series GTHE2 Transceivers

Figure 3-5 shows the clocking scheme for Artix-7 and Zynq-7000 GTPE2 transceivers with Shared Logic included in the core.

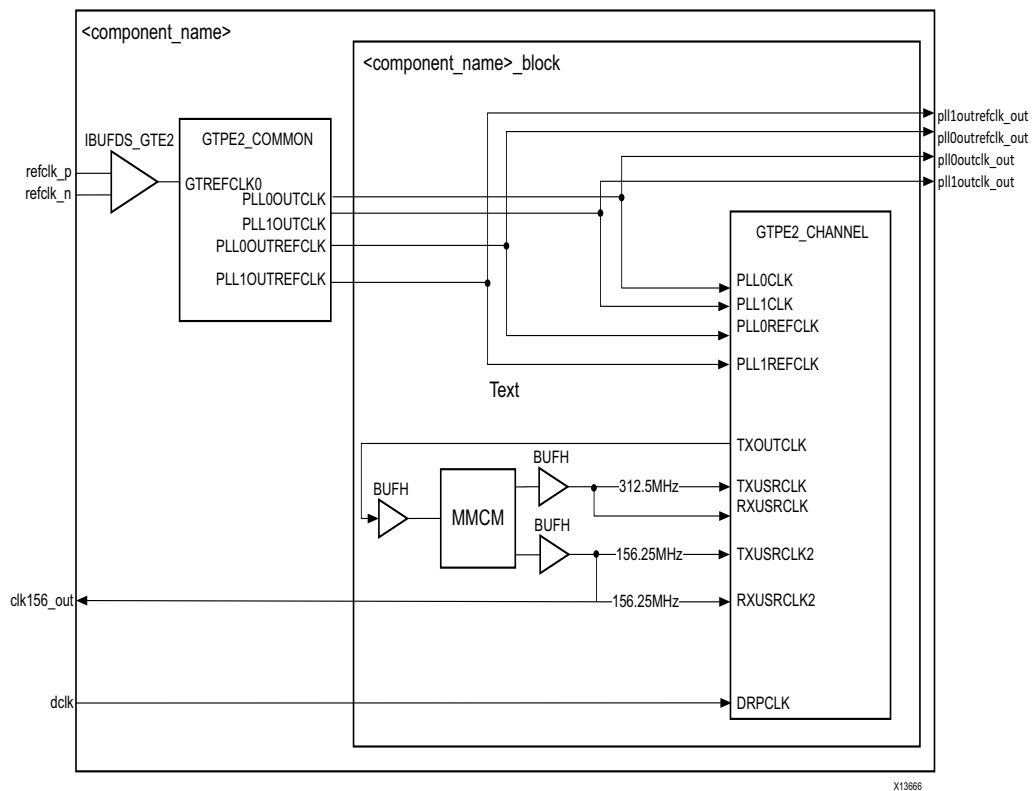


Figure 3-5: Clock Scheme for Artix-7 and Zynq-7000 GTPE2 Transceivers

Figure 3-6 shows the clocking scheme for UltraScale GTHE3 transceivers with Shared Logic included in the core.

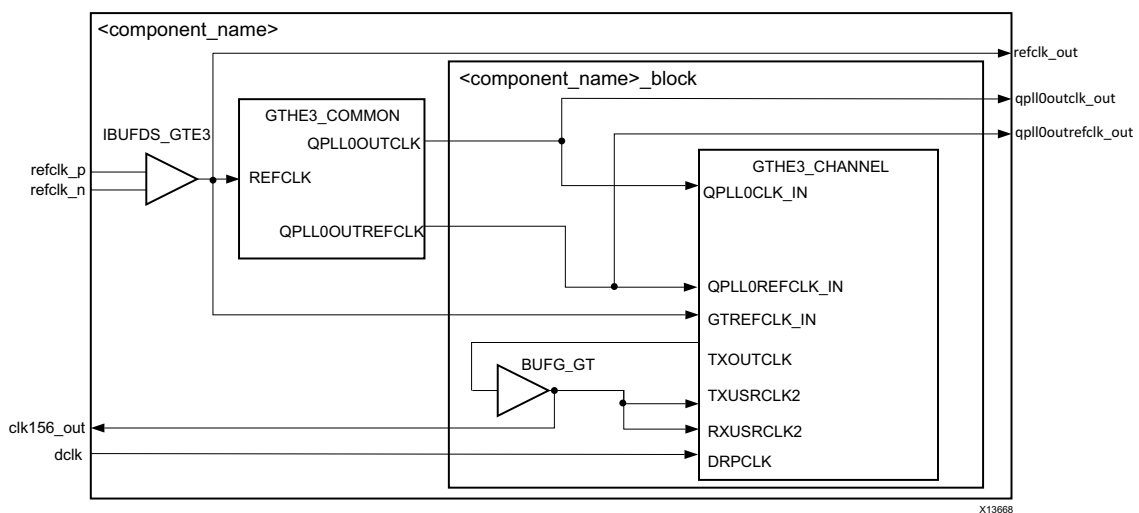


Figure 3-6: Clock Scheme for UltraScale GTHE3 Transceivers

Figure 3-7 shows the clocking scheme for UltraScale GTYE3 transceivers with shared logic included in the core.

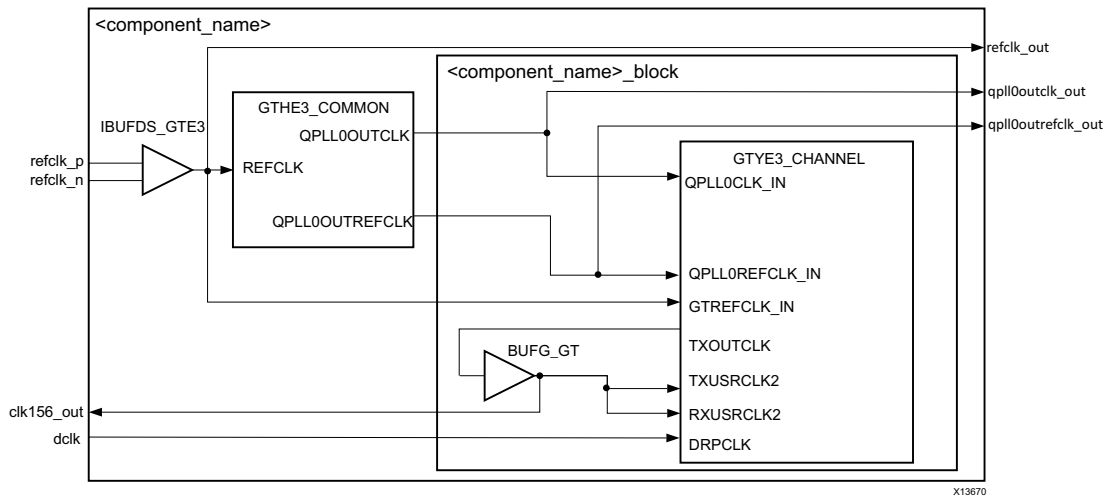


Figure 3-7: Clock Scheme for UltraScale GTYE3 Transceivers with Shared Logic

Figure 3-8 shows the clocking scheme for 7 series and Zynq-7000 GTXE2 transceivers with Shared Logic included in the example design.

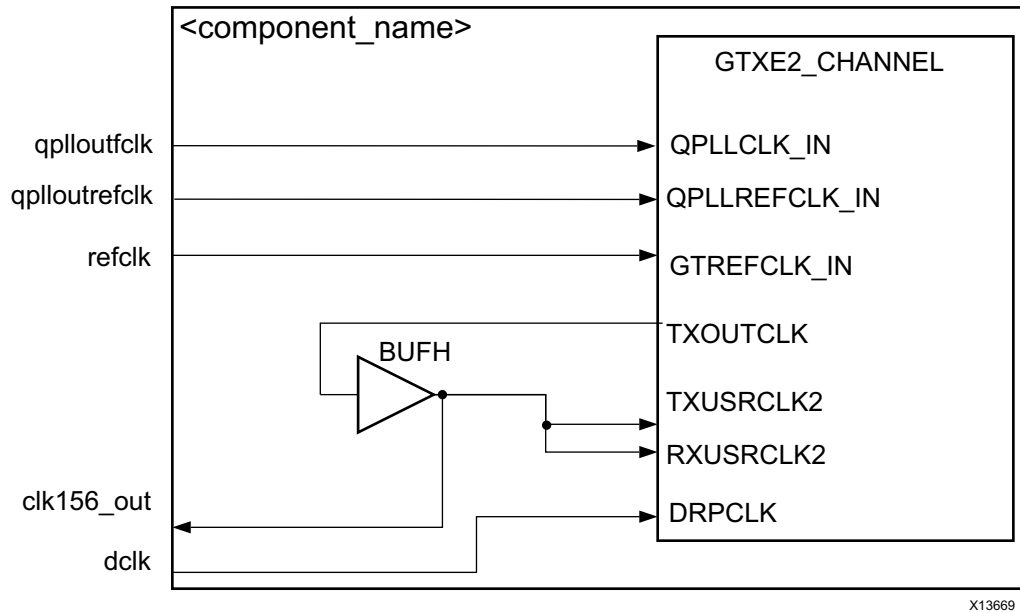
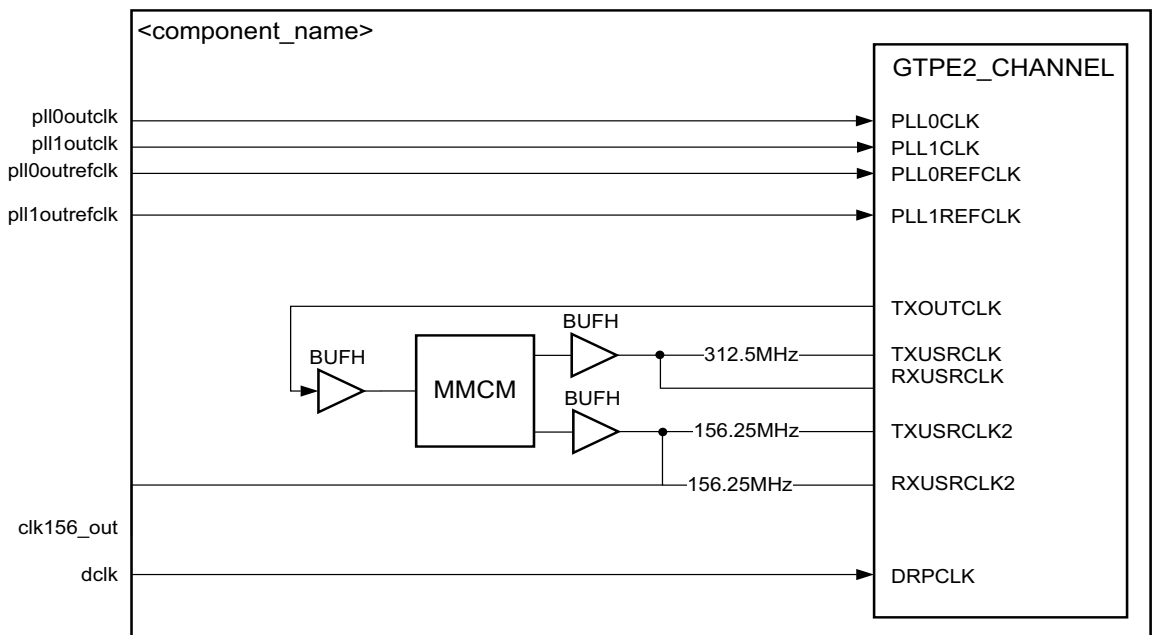


Figure 3-8: Clock Scheme for 7 Series and Zynq-7000 GTXE2 Transceivers

Figure 3-9 shows the clocking scheme for Artix-7 and Zynq-7000 GTPE2 transceivers with Shared Logic included in the example design.



X13667

Figure 3-9: Clock Scheme for Artix-7 and Zynq-7000 GTPE2 Transceivers

Figure 3-10 shows the clocking scheme for 7 series GTHE2 transceivers with Shared Logic included in the example design.

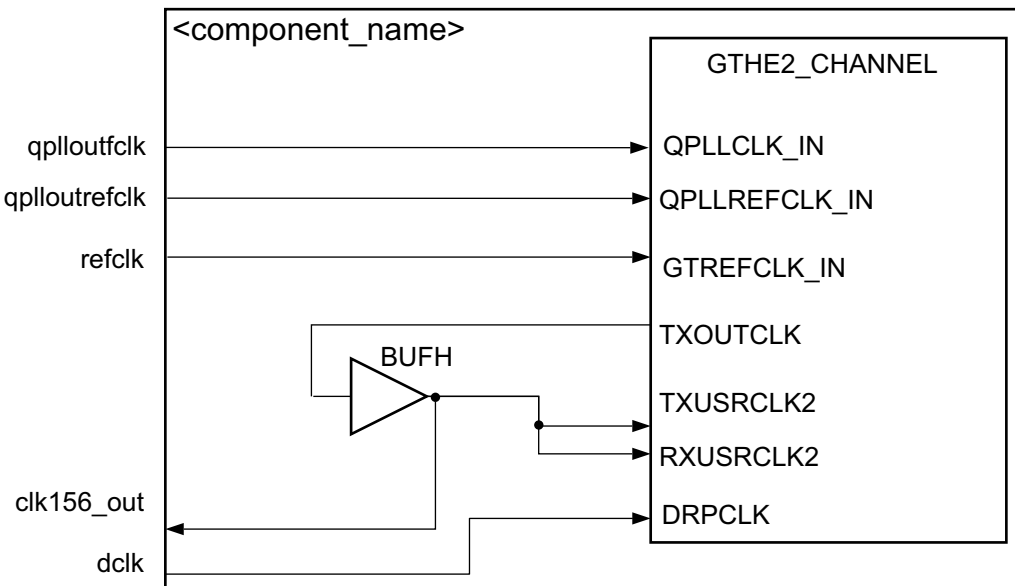


Figure 3-10: Clock Scheme for 7 Series GTHE2 Transceivers



Figure 3-11 shows the clocking scheme for UltraScale GTHE3 transceivers with Shared Logic included in the example design.

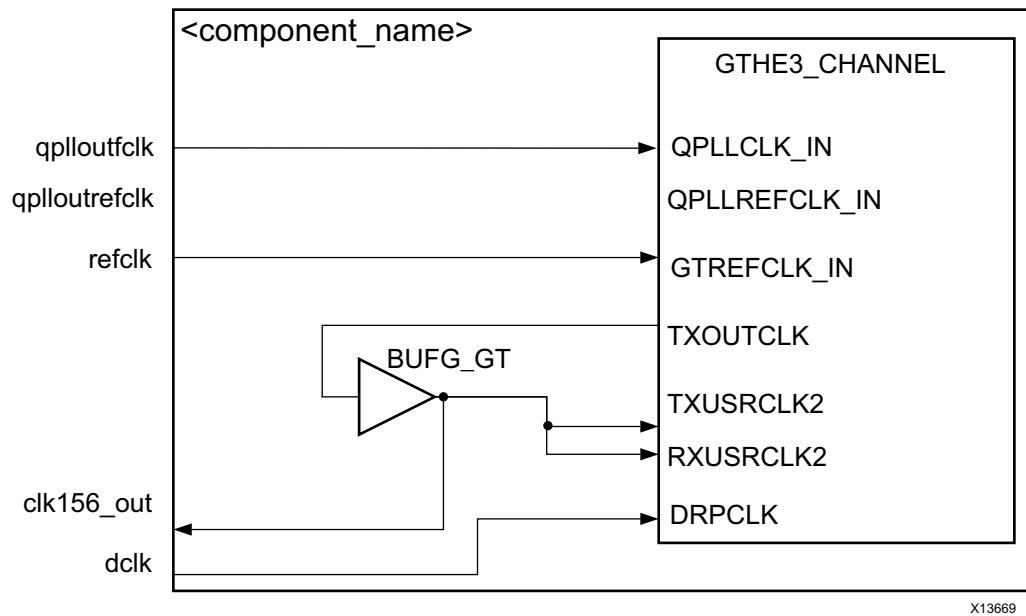


Figure 3-11: Clock Scheme for UltraScale GTHE3 Transceivers

Figure 3-12 shows the clocking scheme for UltraScale GTYE3 transceivers with shared logic included in the example design.

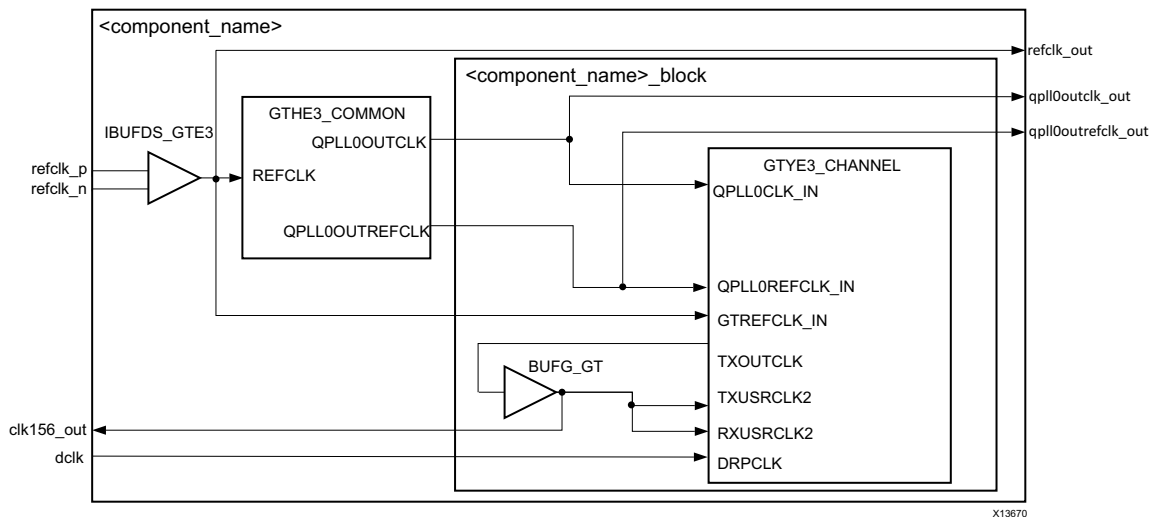


Figure 3-12: Clock Scheme for UltraScale GTYE3 Transceivers

## Changing the clk156 Clock Buffer for 7 Series and Zynq-7000 Devices

The default clock buffer on TXOUTCLK is a BUFH. If you require a different clock buffer, for example a BUFG, unlink the IP and alter the HDL. The clock buffer is instanced in the `<core name>_cl_clocking.v[hd]` file.

For information about unlinking IP see the *Vivado Design Suite User Guide, Designing with IP* (UG896) [Ref 7].

## Resets

See [Table 2-5](#) for information on the reset ports. The asynchronous reset is internally synchronized to reset registers within the RXAUI core.

## Design Considerations

This section describes considerations that can apply in particular design cases.

### Multiple Core Instances

There are several ways to instance 2 RXAUI cores:

1. The simplest way if all transceivers are to be located in the same QUAD is to customize one RXAUI core with shared logic in the core, and the other with shared logic in the example design. The common PLL ports can then be directly connected between the two cores allowing the transceiver common PLL to be shared between the two cores.



**CAUTION!** *In UltraScale devices with this configuration, the RXAUI with shared logic in the core controls the reset of the quad PLL because the other RXAUI core is unable to issue a reset to the quad PLL.*

2. For finer grained control, customize the core with shared logic in the example design. You then have to implement the common PLL in your own design, and connect it to the cores.

Due to the transceiver phase alignment procedure, `clk156_out` must be generated from the transceiver `txoutclk` port and is not shareable with another core instance. See the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [Ref 2], *7 Series FPGAs GTP Transceivers User Guide* (UG482) [Ref 3], and *UltraScale Architecture GTH Transceivers User Guide* (UG576) [Ref 4] for details on sharing the reference clock and any limitations.

Figure 3-13 shows two RXAUI cores, showing the ports that are connected. RXAUI\_1 core has the Shared Logic included in the core and RXAUI\_0 has the Shared Logic included in the example design.

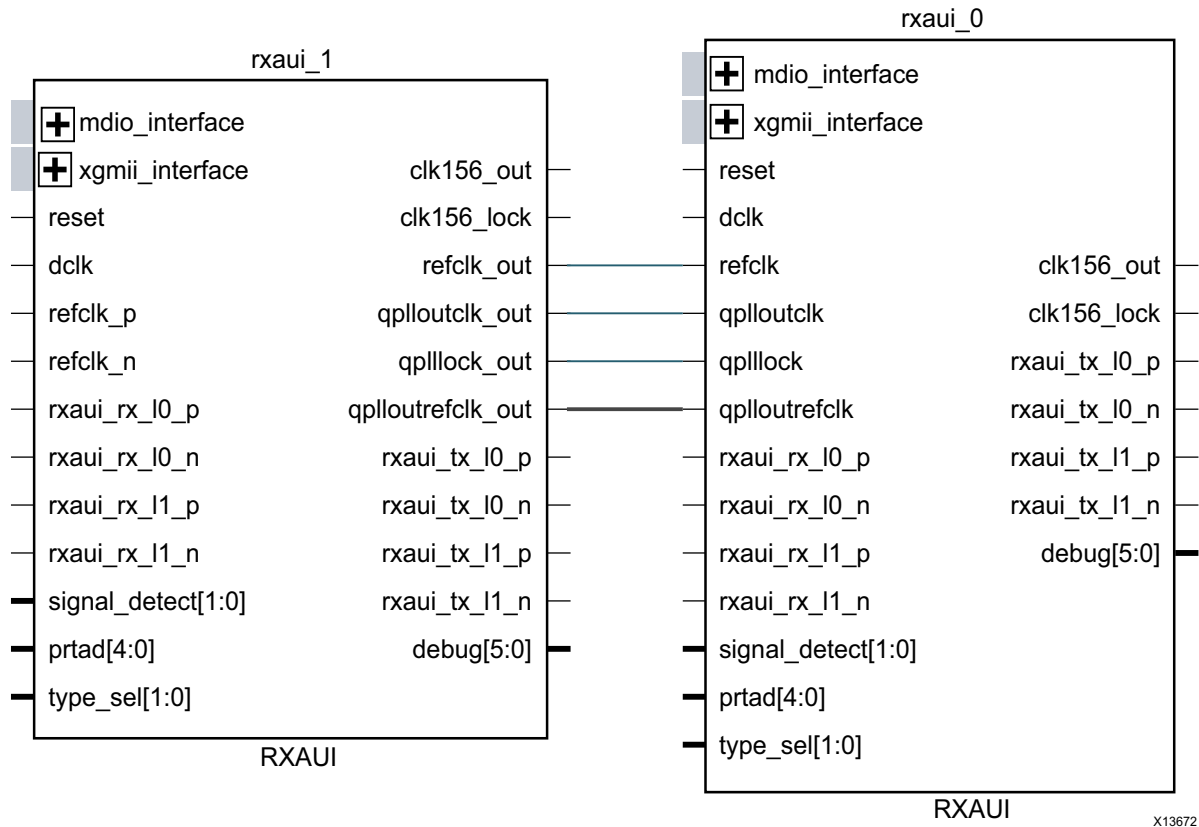


Figure 3-13: RXAUI Cores Showing the Two Possible Shared Logic Configurations for 7 Series

## Receiver Termination

See the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [Ref 2] and the *7 Series FPGAs GTP Transceivers User Guide* (UG482) [Ref 3].

## Protocol Description

### Internal Data Interfaces

The 64-bit single-data rate (SDR) client-side interface is based upon the 32-bit XGMII-like interface. The bus is demultiplexed from 32- bits wide to 64-bits wide on a single rising clock edge. This demultiplexing is done by extending the bus upwards so that there are now eight lanes of data numbered 0-7; the lanes are organized such that data appearing on lanes 4–7 is transmitted or received *later* in time than that in lanes 0–3.

The mapping of lanes to data bits is shown in [Table 3-1](#). The lane number is also the index of the control bit for that particular lane; for example, `XGMII_TXC[2]` and `XGMII_TXD[23:16]` are the control and data bits respectively for lane 2.

**Table 3-1: XGMII\_TXD, XGMII\_RXD Lanes for Internal 64-bit Client-Side Interface**

Lane	XGMII_TXD, XGMII_RXD Bits
0	7:0
1	15:8
2	23:16
3	31:24
4	39:32
5	47:40
6	55:48
7	63:56

## Control Character Definitions

Reference is regularly made to certain XGMII control characters signifying Start, Terminate, Error and others. These control characters all have in common that the control line for that lane is 1 for the character and a certain data byte value. The relevant characters are defined in the *IEEE Std. 802.3-2012* and are reproduced in [Table 3-2](#) for reference.

**Table 3-2: Partial list of XGMII Characters**

Data (Hex)	Control	Name, Abbreviation
00 to FF	0	Data (D)
07	1	Idle (I)
FB	1	Start (S)
FD	1	Terminate (T)
FE	1	Error (E)

## Interfacing to the Transmit Client Interface

The timing of a data frame transmission using the internal 64-bit client-side interface is shown in [Figure 3-14](#). The beginning of the data frame is shown by the presence of the Start character (the /S/ codegroup in lane 4 of [Figure 3-14](#)) followed by data characters in lanes 5, 6, and 7. Alternatively the start of the data frame can be marked by the occurrence of a Start character in lane 0, with the data characters in lanes 1 to 7.

When the frame is complete, it is completed by a Terminate character (the T in lane 1 of Figure 3-14). The Terminate character can occur in any lane; the remaining lanes are padded by XGMII idle characters.

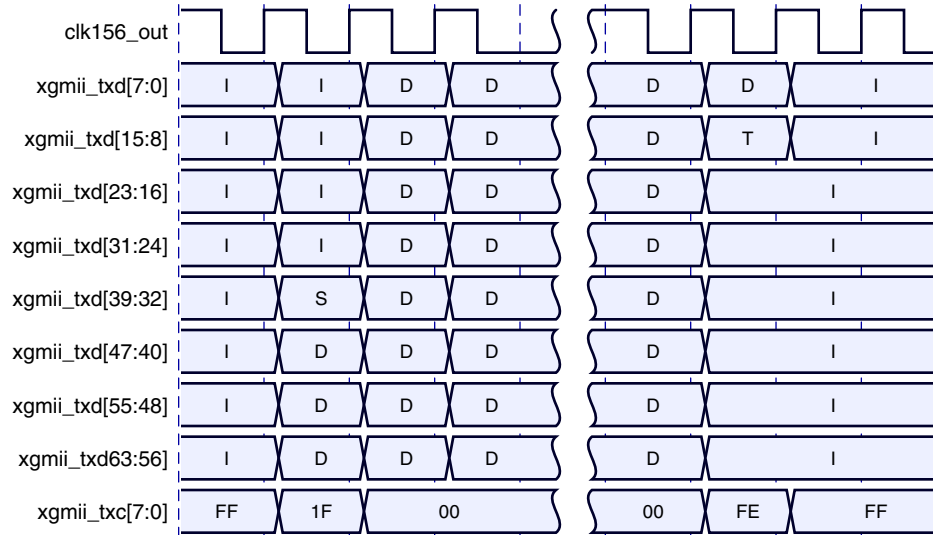


Figure 3-14: Normal Frame Transmission Across the Internal 64-bit Client-Side I/F

Figure 3-15 depicts a similar frame to that in Figure 3-14, with the exception that this frame is propagating an error. The error code is denoted by the letter E, with the relevant control bits set.

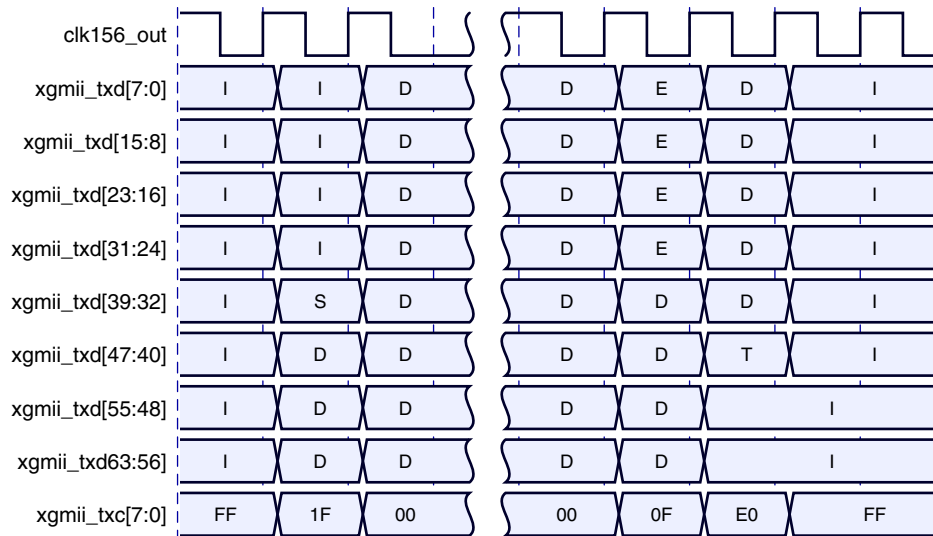
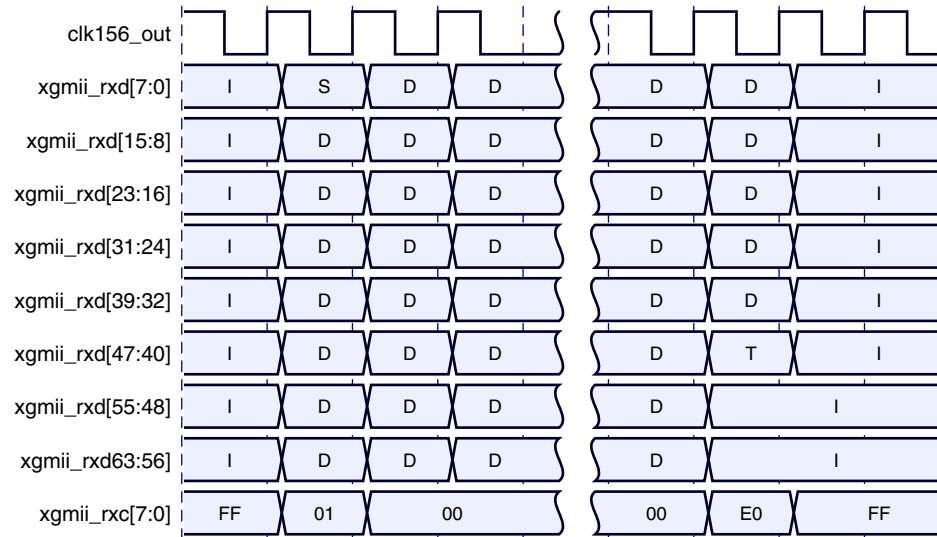


Figure 3-15: Frame Transmission with Error Across Internal 64-bit Client-Side I/F

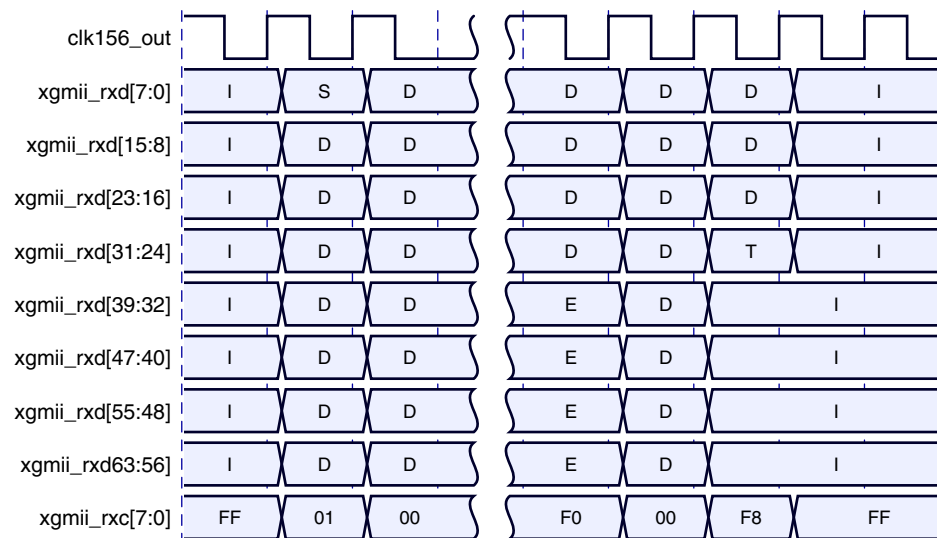
## Interfacing to the Receive Client Interface

The timing of a normal inbound frame transfer is shown in [Figure 3-16](#). As in the transmit case, the frame is delimited by a Start character (S) and by a Terminate character (T). The Start character in this implementation can occur in either lane 0 or in lane 4. The Terminate character, T, can occur in any lane.



**Figure 3-16: Frame Reception Across the Internal 64-bit Client Interface**

[Figure 3-17](#) shows an inbound frame of data propagating an error. In this instance, the error is propagated in lanes 4 to 7, shown by the letter E.



**Figure 3-17: Frame Reception with Error Across the Internal 64-bit Client Interface**

## MDIO Interface

The Management Data Input/Output (MDIO) interface is a simple, low-speed 2-wire interface for management of the RXAUI core consisting of a clock signal and a bidirectional data signal. It is defined in clause 45 of *IEEE Standard 802.3-2012*.

An MDIO bus in a system consists of a single Station Management (STA) master management entity and several MDIO Managed Device (MMD) slave entities. [Figure 3-18](#) illustrates a typical system. All transactions are initiated by the STA entity. The RXAUI core implements an MMD.

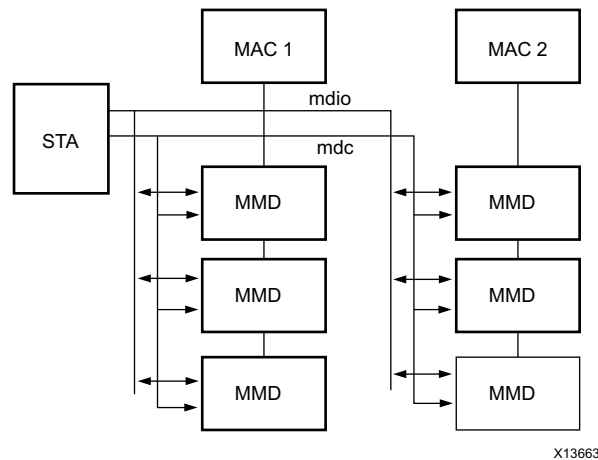


Figure 3-18: A Typical MDIO-Managed System

If implemented, the MDIO interface is implemented as four unidirectional signals. These can be used to drive a 3-state buffer either in the FPGA SelectIO™ interface buffer or in a separate device.

The `type_sel` port is registered into the core at FPGA configuration and core hard or soft reset; changes after that time are ignored by the core. [Table 3-3](#) shows the mapping of the `type_sel` setting to the implemented register map.

Table 3-3: Mapping of `type_sel` Port Settings to MDIO Register Type

<code>type_sel</code> setting	MDIO Register	Description
00 or 01	10GBASE-X PCS/PMA	When driving a 10GBASE-X PHY
10	DTE XGXS	When connected to a 10GMAC through XGMII
11	PHY XGXS	When connected to a PHY through XGMII

The `prtad[4:0]` port sets the port address of the core instance. Multiple instances of the same core can be supported on the same MDIO bus by setting the `prtad[4:0]` to a unique value for each instance; the RXAUI core ignores transactions with the PRTAD field set to a value other than that on its `prtad[4:0]` port.

## MDIO Transactions

The MDIO interface should be driven from a STA master according to the protocol defined in *IEEE Std. 802.3-2012*. An outline of each transaction type is described in the following sections. In these sections, these abbreviations apply:

- PRE: preamble
- ST: start
- OP: operation code
- PRTAD: port address
- DEVAD: device address
- TA: turnaround

### Set Address Transaction

Figure 3-19 shows an Address transaction defined by OP = 00. Set Address is used to set the internal 16-bit address register of the RXAUI core for subsequent data transactions (called the current address in the following sections).

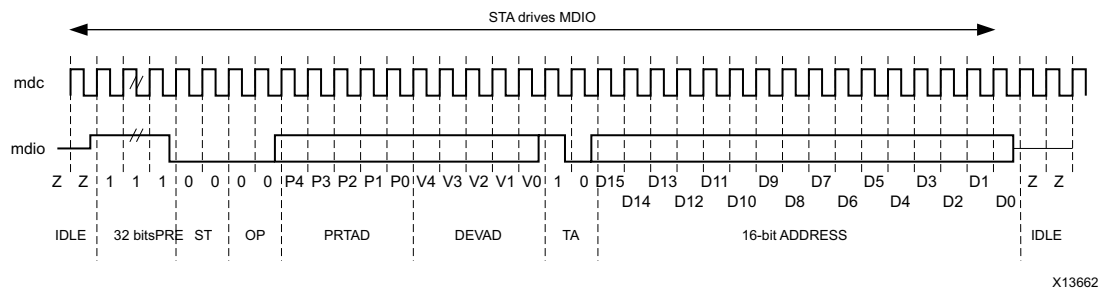


Figure 3-19: MDIO Set Address Transaction

### Write Transaction

Figure 3-20 shows a Write transaction defined by OP = 01. The RXAUI core takes the 16-bit word in the data field and writes it to the register at the current address.

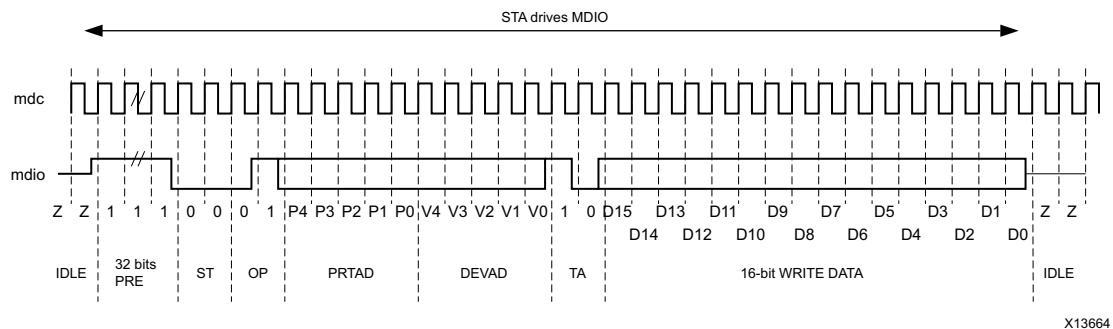


Figure 3-20: MDIO Write Transaction



### Read Transaction

Figure 3-21 shows a Read transaction defined by OP = 11. The RXAUI core returns the 16-bit word from the register at the current address.

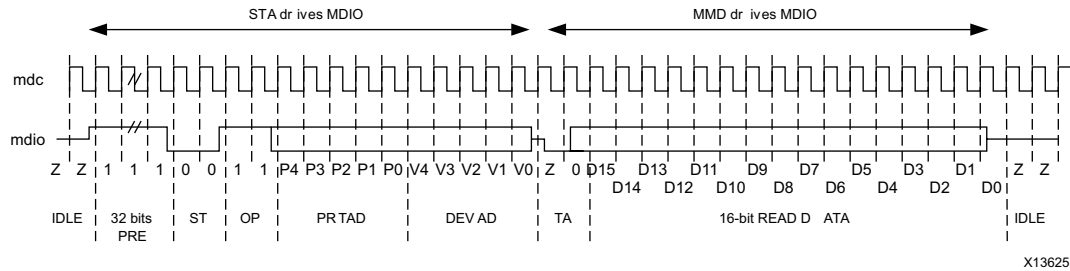


Figure 3-21: MDIO Read Transaction

### Post-Read-increment-address Transaction

Figure 3-22 shows a Post-read-increment-address transaction, defined by OP = 10. The RXAUI core returns the 16-bit word from the register at the current address then increments the current address. This allows sequential reading or writing by a STA master of a block of register addresses.

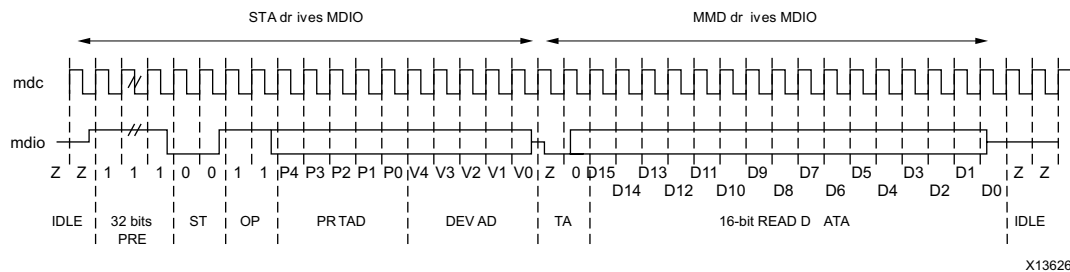


Figure 3-22: MDIO Read-and-increment Transaction

For detail on the MDIO registers, see [MDIO Interface Registers](#).

# Design Flow Steps

This chapter describes customizing and generating the core, constraining the core, and the simulation, synthesis and implementation steps that are specific to this IP core. More detailed information about the standard Vivado® design flows and the IP integrator can be found in the following Vivado Design Suite user guides:

- *Vivado Design Suite User Guide: Designing IP Subsystems using IP Integrator* (UG994) [\[Ref 6\]](#)
- *Vivado Design Suite User Guide: Designing with IP* (UG896) [\[Ref 7\]](#)
- *Vivado Design Suite User Guide: Getting Started* (UG910) [\[Ref 8\]](#)
- *Vivado Design Suite User Guide: Logic Simulation* (UG900) [\[Ref 9\]](#)

---

## Customizing and Generating the Core

You can customize the IP for use in your design by specifying values for the various parameters associated with the IP core using the following steps:

1. Select the IP from the IP catalog.
2. Double-click on the selected IP or select the Customize IP command from the toolbar or popup menu.

For details, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [\[Ref 7\]](#) and the *Vivado Design Suite User Guide: Getting Started* (UG910) [\[Ref 8\]](#).

**Note:** Figures in this chapter are illustrations of the RXAUI core in the Vivado Integrated Design Environment (IDE). This layout might vary from the current version.

Figure 4-1 displays the main screen for customizing the RXAUI core.

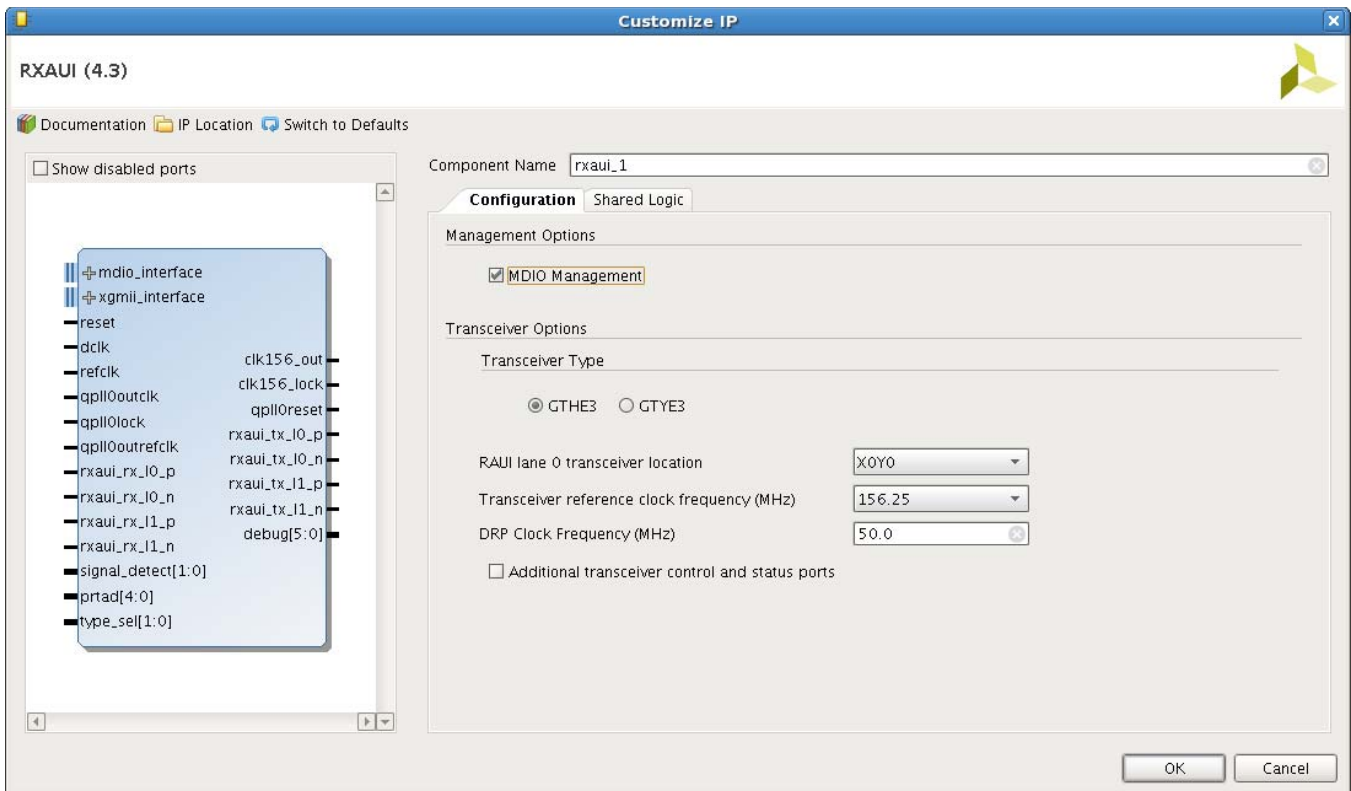


Figure 4-1: RXAUI Main Screen

For general help with starting and using the Vivado IDE, see the documentation supplied with the Vivado Design Suite.

## Component Name

The component name is used as the base name of the output files generated for the core. Names must begin with a letter and must be composed from the following characters: a through z, 0 through 9 and "\_" (underscore).

## MDIO Management

Select this option to implement the MDIO interface for managing the core. De-select the option to remove the MDIO interface and expose a simple bit vector to manage the core. The MDIO interface is implemented by default.

## Transceiver Type

This option is only available for Virtex UltraScale devices that contain both GTHE3 and GTYE3 transceivers; select the transceiver type for these devices.

## RXAUI Lane 0 Transceiver Location

This option is only available for UltraScale devices. Select the X/Y coordinate for the lowest numbered transceiver in the Quad that is used by the RXAUI core. For example, selecting X0Y0 implements XAUI lane 0 in X0Y0; lane 1 in X0Y1. The selected transceivers are specified in both the core and example design XDC files. If needed, this placement selection can be overridden by using constraints in a user XDC file. See [Transceiver Placement](#) for more information.

## Transceiver Reference Clock Frequency (MHz)

This option is only available for UltraScale devices. Select the desired transceiver reference clock frequency from 125 MHz, 156.25 MHz or 312.5 MHz.

## DRP Clock Frequency (MHz)

Enter the frequency of the DRP clock (the dclk input of the core). For UltraScale, 7 Series, and Zynq-7000 AP SoC devices, this value is used to set the target frequency for Out of Context synthesis. Additionally, for UltraScale devices, this frequency information is passed down to the UltraScale Transceiver Wizard, contained within the RXAUI core, where it is used to generate correct timer durations for the transceiver reset/initialization circuitry.

## Additional Transceiver Control and Status Ports

Select if GT control and status ports such as DRP, PRBS, RX Equalizer and TX Driver are required.

## Shared Logic

Select whether the transceiver Quad PLL and differential reference clock buffer is included in the core itself or in the example design (see [Shared Logic](#) for more information).

Figure 4-2 displays the Shared Logic tab for the RXAUI core.

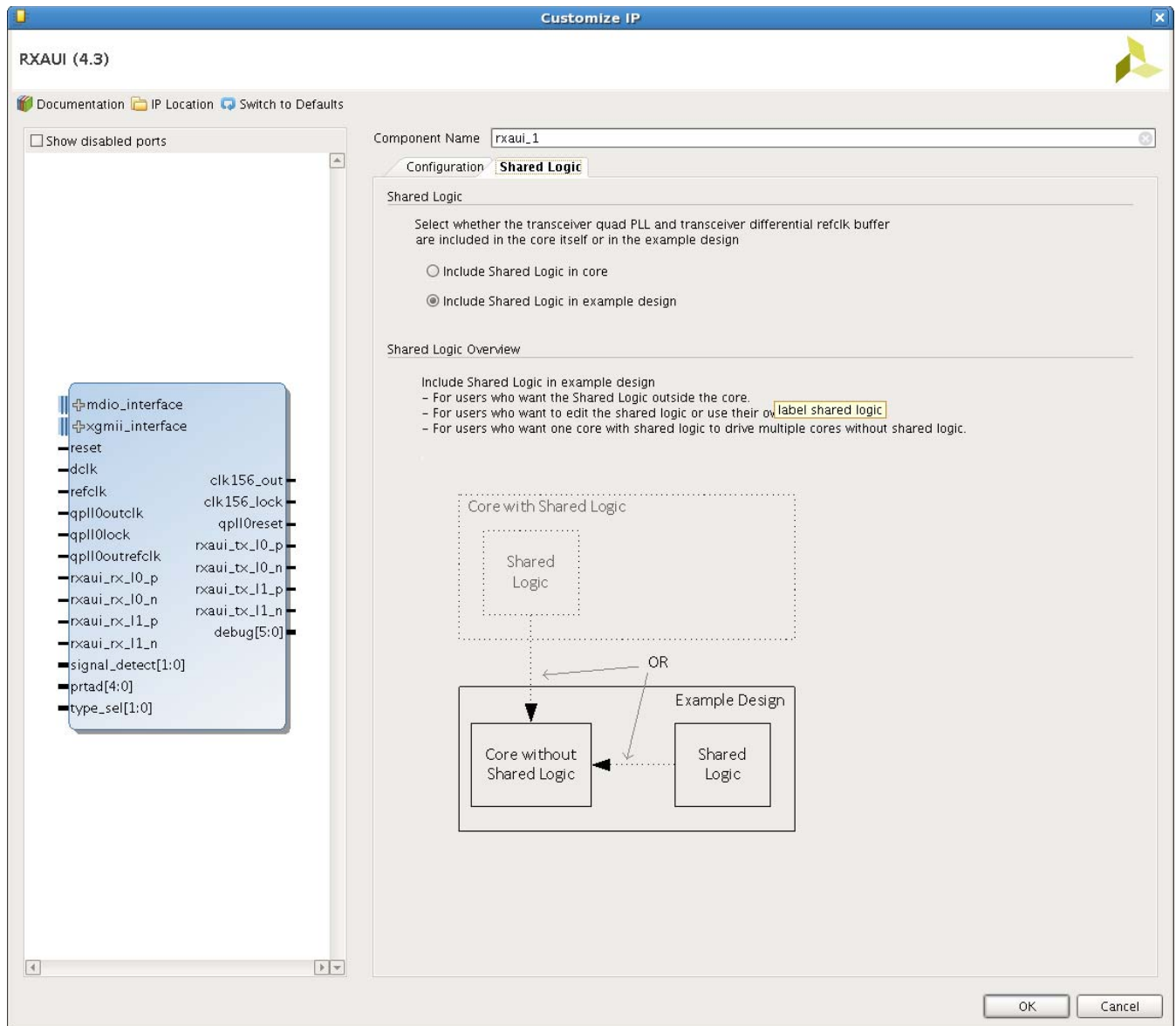


Figure 4-2: RXAUI Shared Logic Tab

## User Parameters

Table 4-1 shows the relationship between the fields in the Vivado IDE and the User Parameters (which can be viewed in the Tcl console).

Table 4-1: Vivado IDE Parameter to User Parameter Relationship

Vivado IDE Parameter/Value <sup>(1)</sup>	User Parameter/Value <sup>(1)</sup>	Default Value
MDIO Management	Mdio_Management	true
Shared Logic	SupportLevel	0
Include Shared Logic in core	1	
Include Shared Logic in example design	0	
Additional transceiver control and status ports	TransceiverControl	false
Transceiver Type	vu_gt_type	GTHE3
Transceiver reference clock frequency (MHz)	RefClkRate	156.25
RXAUI lane 0 transceiver location	Locations	X0Y0
DRP Clock Frequency (MHz)	DRPCLK_FREQ	50.0

### Notes:

- Parameter values are listed in the table where the Vivado IDE parameter value differs from the user parameter value. Such values are shown in this table as indented below the associated parameter.

---

## Output Generation

For details, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 7]

---

## Constraining the Core

This chapter describes how to constrain a design containing the RXAUI core. An XDC file is applied to the core instance. This XDC is available through the **IP Sources** view under **Synthesis**. No modification is required to this file.

There are some additional constraints required that are design specific such as transceiver location constraints. These are detailed in this chapter and an example of such constraints can be found in the example design. See [Chapter 5, Example Design](#), for a complete description of the Vivado Design Suite output files.



**CAUTION!** *Not all constraints are relevant to specific implementations of the core; consult the XDC created with the core instance to see exactly what constraints are relevant.*

## Required Constraints

This section defines the additional constraint requirements for the core. Constraints are provided with an XDC file. An XDC is provided with the HDL example design to give a starting point for constraints for your design. The following constraints are required.

## Clock Frequencies

DCLK should be specified:

```
create_clock -name dclk -period 20.000 [get_ports dclk]
```

This constraint defines the frequency of DCLK that is supplied to the transceivers. The example design uses a nominal 50 MHz clock.

## Clock Management

The Dune Networks RXAUI core has two clock domains:

- The `clk156_out` domain derived from the TXOUTCLK output of the transceiver. The core XDC applies a `create_clock` that propagates to the `clk156_out` output port. No user XDC is required.
- The `dclk` domain. This must be constrained outside of the core as described in [Clock Frequencies](#).

## Transceiver Placement

To constrain the placement of the transceivers using X0Y0 terminology the following constraints should be used.

### *Shared Logic in Example Design*

#### 7 Series GTH Transceivers

```
set_property LOC GTHE2_CHANNEL_X0Y0 [get_cells rxai_support_i/rxai_i/*/gt0_wrapper_i/gthe2_i]
set_property LOC GTHE2_CHANNEL_X0Y1 [get_cells rxai_support_i/rxai_i/*/gt1_wrapper_i/gthe2_i]
```

#### 7 Series GTX Transceivers

```
set_property LOC GTXE2_CHANNEL_X0Y0 [get_cells rxai_support_i/rxai_i/*/gt0_wrapper_i/gtxe2_i]
set_property LOC GTXE2_CHANNEL_X0Y1 [get_cells rxai_support_i/rxai_i/*/gt1_wrapper_i/gtxe2_i]
```

## 7 Series GTP Transceivers

```
set_property LOC GTPE2_CHANNEL_X0Y0 [get_cells rxau_i/rxau_i/**/
gt0_wrapper_i/gtpe2_i]
set_property LOC GTPE2_CHANNEL_X1Y0 [get_cells rxau_i/rxau_i/**/
gt1_wrapper_i/gtpe2_i]
```

## UltraScale Transceivers

The following example illustrates the placement of GTHE3 transceivers when the shared logic is in the example design. To move the location of the RXAUI core using XDC constraints, change the X/Y coordinates to your chosen location. Alternatively the RXAUI core placement can be selected from the core customization screen in the Vivado IDE prior to core generation.

For GTYE3 transceivers: replace the GTHE3 string with GTYE3 and the gthe3 string with gtye3 in the following example syntax.

```
set_property LOC GTHE3_CHANNEL_X0Y0 [get_cells rxau_i/rxau_i/**/< CompName
>_gt_i/inst/gen_gtwizard_gthe3_top.< CompName >_gt_gtwizard_gthe3_inst/
gen_gtwizard_gthe3.gen_channel_container[*].gen_enabled_channel.gthe3_channel_wrapp
er_inst/channel_inst/
gthe3_channel_gen.gen_gthe3_channel_inst[0].GTHE3_CHANNEL_PRIM_INST]
set_property LOC GTHE3_CHANNEL_X0Y1 [get_cells rxau_i/rxau_i/**/< CompName
>_gt_i/inst/gen_gtwizard_gthe3_top.< CompName >_gt_gtwizard_gthe3_inst/
gen_gtwizard_gthe3.gen_channel_container[*].gen_enabled_channel.gthe3_channel_wrapp
er_inst/channel_inst/
gthe3_channel_gen.gen_gthe3_channel_inst[1].GTHE3_CHANNEL_PRIM_INST]
set_property LOC GTHE3_COMMON_X0Y0 [get_cells rxau_i/rxau_i/**/common_inst/
common_inst/gthe3_common_gen.GTHE3_COMMON_PRIM_INST]
```

## Shared Logic in Core

### 7 Series GTH Transceivers

```
set_property LOC GTHE2_CHANNEL_X0Y0 [get_cells rxau_i/rxau_block_i/**/
gt0_wrapper_i/gthe2_i]
set_property LOC GTHE2_CHANNEL_X0Y1 [get_cells rxau_i/rxau_block_i/**/
gt1_wrapper_i/gthe2_i]
```

### 7 Series GTX Transceivers

```
set_property LOC GTXE2_CHANNEL_X0Y0 [get_cells rxau_i/rxau_block_i/**/
gt0_wrapper_i/gtxe2_i]
set_property LOC GTXE2_CHANNEL_X0Y1 [get_cells rxau_i/rxau_block_i/**/
gt1_wrapper_i/gtxe2_i]
```

### 7 Series GTP Transceivers

```
set_property LOC GTPE2_CHANNEL_X0Y0 [get_cells rxau_i/rxau_block_i/**/
gt0_wrapper_i/gtpe2_i]
set_property LOC GTPE2_CHANNEL_X1Y0 [get_cells rxau_i/rxau_block_i/**/
gt1_wrapper_i/gtpe2_i]
```



## UltraScale Transceivers

The following example illustrates the placement of GTHE3 transceivers when the shared logic is in the core. To move the location of the RXAUI core using XDC constraints, change the X/Y coordinates to your chosen location. Alternatively the RXAUI core placement can be selected from the core customization screen in the Vivado IDE prior to core generation.

For GTYE3 transceivers, replace the GTHE3 string with GTYE3 and the gthe3 string with gtye3 in the following example syntax.

```
set_property LOC GTHE3_CHANNEL_X0Y0 [get_cells rxau_i/*/rxau_block_i/< CompName
>_gt_i/inst/gen_gtwizard_gthe3_top.< CompName >_gt_gtwizard_gthe3_inst/
gen_gtwizard_gthe3.gen_channel_container[*].gen_enabled_channel.gthe3_channel_wrapp
er_inst/channel_inst/
gthe3_channel_gen.gen_gthe3_channel_inst[0].GTHE3_CHANNEL_PRIM_INST]
set_property LOC GTHE3_CHANNEL_X0Y1 [get_cells rxau_i/*/rxau_block_i/< CompName
>_gt_i/inst/gen_gtwizard_gthe3_top.< CompName >_gt_gtwizard_gthe3_inst/
gen_gtwizard_gthe3.gen_channel_container[*].gen_enabled_channel.gthe3_channel_wrapp
er_inst/channel_inst/
gthe3_channel_gen.gen_gthe3_channel_inst[1].GTHE3_CHANNEL_PRIM_INST]
set_property LOC GTHE3_COMMON_X0Y0 [get_cells rxau_i/*/rxau_gt_common_i/< CompName
>_gt_common_wrapper_i/common_inst/gthe3_common_gen.GTHE3_COMMON_PRIM_INST]
```

---

## Simulation

Simulation of the RXAUI solution at the core level is not supported without the addition of a test bench (not supplied). Simulation of the example design is supported.

For comprehensive information about Vivado simulation components, as well as information about using supported third party tools, see the *Vivado Design Suite User Guide: Logic Simulation* (UG900) [Ref 9].

---

## Synthesis and Implementation

The RXAUI solution this is a mix of both encrypted and unencrypted source. Only the unencrypted sources are visible and optionally editable by using the Unlink IP Vivado option.

For details about synthesis and implementation, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 7].

# Example Design

This chapter provides information about the example design, including a description of the files and the directory structure generated by the Xilinx® Vivado® Design Suite, the purpose and contents of the provided scripts, the contents of the example HDL wrappers, and the operation of the demonstration test bench.

## Example Design

Figure 5-1 illustrates the clock and reset enabled configuration of the example design for 7 series devices with shared logic in the core.

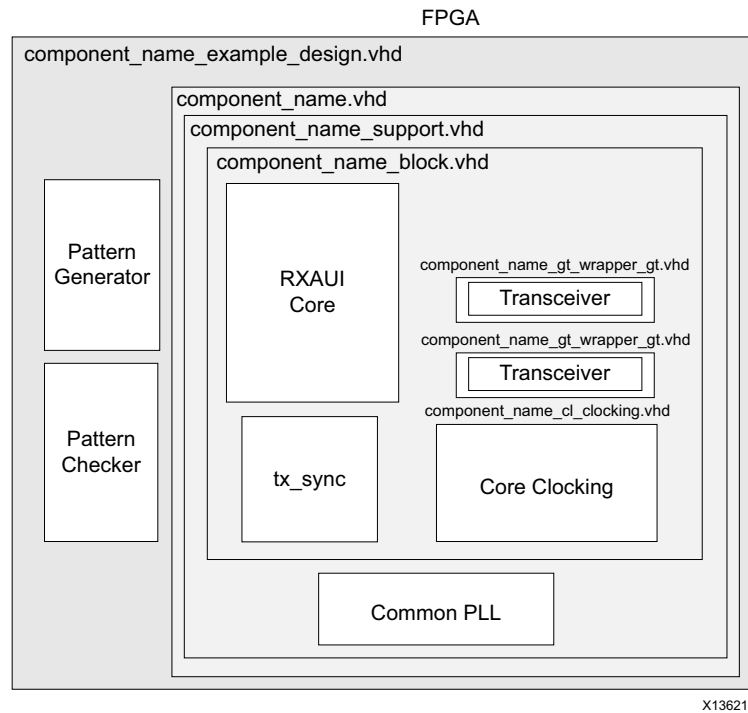
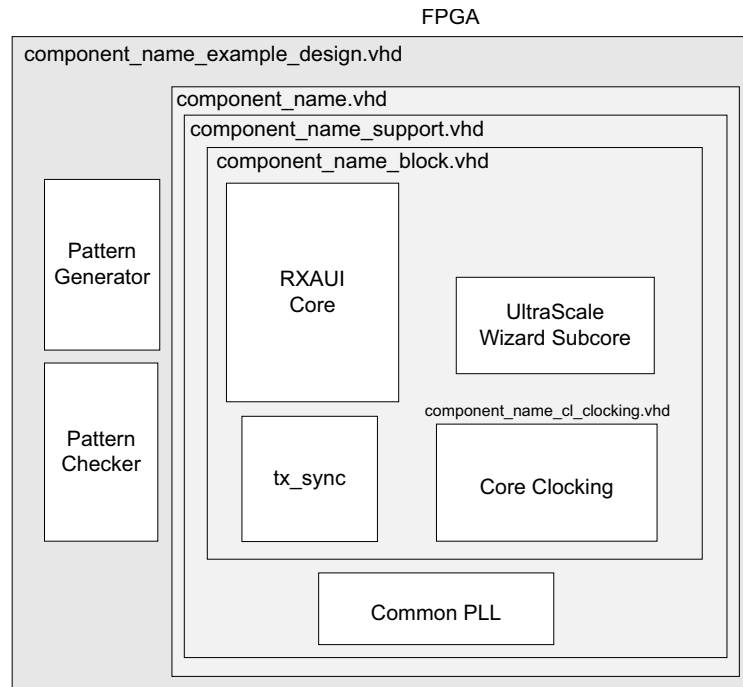


Figure 5-1: RXAUI Example Design Test Bench – Clock and Reset Enabled for 7 Series

Figure 5-1 illustrates the clock and reset enabled configuration of the example design for UltraScale architecture with shared logic in the core.



X1709F\_001.1.1.16

Figure 5-2: RXAUI Example Design and Test Bench – Clock and Reset Enabled for UltraScale Architecture

The RXAUI example design consists of the following:

- Clock buffers for `dc1k`
- Simple XGMII pattern generator and checker
- An instance of the core (Shared Logic included in the core) or the support level module which contains the core, common PLL, and shared reset module (7 series)

The RXAUI Design Example has been tested with Xilinx Vivado Design Suite and Mentor Graphics Questa Simulator (QuestaSim) (the versions of these tools are available in the [Xilinx Design Tools: Release Notes Guide](#)).

## Test Bench

The example design demonstration test bench is a simple VHDL or Verilog program to exercise the example design and the core itself. It simulates an instance of the example design that is externally looped back. It generates all the required clocks and resets and waits for successful pattern checking to complete. If it fails to detect successful pattern checking within the time limit defined in the test bench, it produces an error.

# Verification, Compliance, and Interoperability

The RXAUI core has been verified using both simulation and hardware testing.

---

## Simulation

A highly parameterizable transaction-based simulation test suite has been used to verify the core. Tests included:

- Register access over MDIO
  - Loss and re-gain of synchronization
  - Loss and re-gain of alignment
  - Frame transmission
  - Frame reception
  - Clock compensation
  - Recovery from error conditions
- 

## Hardware Testing

The core has been used in several hardware test platforms within Xilinx. In particular, the core has been used in a test platform design with the Xilinx® 10-Gigabit Ethernet MAC core. This design comprises the MAC, RXAUI, a ping loopback FIFO, and a test pattern generator all under embedded MicroBlaze™ processor control. This design has been used for interoperability testing at Dune Networks.

# Migrating and Upgrading

This appendix contains information about migrating a design from ISE® to the Vivado® Design Suite, and for upgrading to a more recent version of the IP core. For customers upgrading in the Vivado Design Suite, important details (where applicable) about any port changes and other impact to user logic are included.

---

## Device Migration

If you are migrating from a 7 series GTX or GTH device to an UltraScale GTH device, the prefixes of the optional transceiver debug ports for single-lane cores are changed from "gt0", "gt1" to "gt", and the suffix "\_in" and "\_out" are dropped. For multi-lane cores, the prefixes of the optional transceiver debug ports gt(n) are aggregated into a single port. For example: `gt0_gtrxreset` and `gt1_gtrxreset` now become `gt_gtrxreset [1:0]`. This is true for all ports, with the exception of the DRP buses which follow the convention of `gt(n)_drpxyz`.

It is important to update your design to use the new transceiver debug port names. For more information about migration to UltraScale devices, see the *UltraScale Architecture Migration Methodology Guide* (UG1026) [Ref 11].

---

## Upgrading in the Vivado Design Suite

This section provides information about any changes to the user logic or port designations that take place when you upgrade to RXAUI v4.3 in the Vivado Design Suite.

"Include common clocking and resets" is now mapped to "Include shared logic in core". If this option was previously off this now maps to "Include shared logic in example design".

## Parameter Changes

There are no parameter changes between RXAUI v4.0 and RXAUI v4.3.

The `WRAPPER_SIM_GTRESET_SPEEDUP` parameter was previously removed in RXAUI v4.0.

## Port Changes from v4.2 to v4.3

Table B-2 shows the transceiver control and status ports added from RXAUI v4.2 to RXAUI v4.3.

Table B-1: Transceiver Debug Control and Status Added from v4.0 to v4.1<sup>(1)</sup>

Port	Direction	Reason for Change	Default Value
gtN_txinhibit_in	In	Added transceiver Control and Status ports (7 Series families).	Assign default value 0
gt_txinhibit[1:0]	In	Added transceiver Control and Status ports (UltraScale architecture).	Assign default value 0
gt_pcsrsvdin[31:0]	In	Added transceiver Control and Status ports (UltraScale architecture).	Assign default value 0

### Notes:

1. N can be 0 for Channel 0 or 1 for Channel 1.

## Port Changes from v4.1 to v4.2

Between RXAUI v4.1 and RXAUI v4.2, a single output port, `common_pll_reset_out`, was added to the core when targeting Artix-7 devices and only when the shared logic is included in the core. This allows for a direct connection to the corresponding `common_pll_reset` input port that was already present on the core for Artix-7 devices when the shared logic is not included in the core.

## Port Changes from v4.0 to v4.1

Table B-2 shows the transceiver Control and Status ports added from RXAUI v4.0 to RXAUI v4.1.

Table B-2: Transceiver Debug Control and Status Added from v4.0 to v4.1<sup>(1)</sup>

Port	Direction	Default Value
gtN_txpmareset_in	In	0
gtN_txpcsreset_in	In	0
gtN_rxpmareset_in	In	0
gtN_rxpcsreset_in	In	0
gtN_rxpmaresetdone_out	Out	(GTH, GTP) open
gtN_rxbufstatus_out[2:0]	Out	open
gtN_txphaligndone_out	Out	open
gtN_txphinitdone_out	Out	open
gtN_txdlysresetdone_out	Out	open
gtN_cpplllock_out	Out	(GTH) open
gtN_qpplllock_out	Out	(GTX, GTP) open

**Table B-2: Transceiver Debug Control and Status Added from v4.0 to v4.1<sup>(1)</sup>**

Port	Direction	Default Value
gtN_rxcdrhold_in	In	0
gtN_dmonitorout_out	Out	open
gtN_rxcommadet_out	Out	open

**Notes:**

1. N can be 0 for Channel 0 or 1 for Channel 1

## Port Additions in v4.0

Table B-3 shows the transceiver Control and Status ports added in RXAUI v4.0.

**Table B-3: Transceiver Control and Status Ports Added in v4.0<sup>(1)</sup>**

Port	Direction	Default Value
gtN_txresetdone_out	Out	open
gtN_rxresetdone_out	Out	open
gtN_eyesctrigger_in	In	0
gtN_eyesctrreset_in	In	0
gtN_eyesctrdataerror_out	Out	open
gtN_rxrate_in	In	B"000"
gtN_loopback_in	In	B"000"
gtN_rxpolarity_in	In	0
gtN_txpolarity_in	In	0
gtN_rxlpmen_in	In	(GTX, GTH) 0
gtN_rxdfelpmreset_in	In	(GTX, GTH) 0
gtN_rxmonitorsel_in	In	(GTX, GTH) B"00"
gtN_rxmonitorout_out	Out	(GTX, GTH) open
gtN_rxlpmreset_in	In	(GTP) 0
gtN_rxlpmhfold_in	In	(GTP) 0
gtN_rxlpmhfovden_in	In	(GTP) 0
gtN_rxlpmfold_in	In	(GTP) 0
gtN_rxlpmfovden_in	In	(GTP) 0
gtN_txdiffctrl_in	In	B"1010"
gtN_txpostcursor_in	In	B"00000"
gtN_txprecursor_in	In	B"00000"
gtN_rxprbsctrlreset_in	In	0
gtN_rxprbserr_out	Out	open
gtN_rxprbsssel_in	In	B"000"



**Table B-3: Transceiver Control and Status Ports Added in v4.0<sup>(1)</sup> (Cont'd)**

Port	Direction	Default Value
gtN_txprbssel_in	In	B"000"
gtN_txprbsforceerr_in	In	0
gtN_rxdisperr_out	Out	open
gtN_rxnotintable_out	Out	open

**Notes:**

1. N can be 0 for Channel 0 or 1 for Channel 1.

## Port Changes from v3.0 to v4.0

Table B-4 shows the ports that have been added, removed, or re-named between RXAUI v3.0 and RXAUI v4.0.

**Table B-4: Port Changes**

Added	Removed	Notes
clk156_out (output)	clk156 (input)	clk156_out is a clock output that replaces the txoutclk and clk156 pins. It is driven by a BUFH. As before, this clock is not shared with another RXAUI core instance. Remove any clock buffer you had instanced previously in your design.
	txoutclk (output)	
	reset156 (input)	The core now generates its synchronous reset internally.
	mmcm_lock (input)	
	clk312 (input) (GTP only)	The MMCM is located inside the core.
	gt_control (input vector)	Replaced by individual transceiver control pins.
clk156_lock	txlock	txlock output re-named as clk156_lock
debug		This output vector has been resized to 6 bits wide. These bits map to the old debug vector [5:0]. Individual transceiver ports have replaced the removed bits.
refclkout (output)		GTX/GTH: When "Shared logic in core" is selected, refclkout is a new output port than can be connected to the refclk input port of another core.

### DRP Ports

Table B-5 shows the re-naming of DRP ports between versions 3.0 and 4.0.

**Table B-5: DRP Port Name Changes**

3.0	4.0
drp0_addr	gt0_drpaddr
drp0_en	gt0_drpen
drp0_i	gt0_drpd_i
drp0_o	gt0_drpdo
drp0_rdy	gt0_drprdy

Table B-5: **DRP Port Name Changes (Cont'd)**

3.0	4.0
drp0_we	gt0_drpwe
drp0_busy	gt0_drp_busy (GTP only)
drp1_addr	gt1_drpaddr
drp1_en	gt1_drpen
drp1_i	gt1_drpdi
drp1_o	gt1_drpdo
drp1_rdy	gt1_drprdy
drp1_we	gt1_drpwe
drp1_busy	gt1_drp_busy (GTP only)

### QPLL Ports

Table B-6 and Table B-7 shows the re-naming of QPLL ports (GTX/GTH only) between versions 3.0 and 4.0.

 Table B-6: **QPLL Port Name Changes (Shared Logic in Core)**

3.0	4.0
common_pll_clk	qplloutclk_out
common_pll_lock	qplllock_out
common_pll_refclk	qplloutrefclk_out

 Table B-7: **QPLL Port Name Changes (Shared Logic in Example Design)**

3.0	4.0
common_pll_clk	qplloutclk
common_pll_lock	qplllock
common_pll_refclk	qplloutrefclk

### GTP Ports

Table B-8 and Table B-9 shows the re-naming of GTP ports between versions 3.0 and 4.0.

 Table B-8: **GTPE2\_COMMON Port Name Changes (Shared Logic in Core)**

3.0	4.0
common_pll0_clk	pll0outclk_out
common_pll0_lock	pll0lock_out
common_pll0_refclk	pll0outrefclk_out
common_pll1_clk	pll1outclk_out
common_pll1_refclk	pll1outrefclk_out

Table B-9: GTPE2\_COMMON Ports (Shared Logic in Example Design)

3.0	4.0
common_pll0_clk	pll0outclk
common_pll0_lock	pll0lock
common_pll0_refclk	pll0refclk
common_pll1_clk	pll1outclk
common_pll1_refclk	pll1outrefclk

# Debugging

This appendix includes details about resources available on the Xilinx Support website and debugging tools.

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## Finding Help on Xilinx.com

To help in the design and debug process when using the RXAUI core, the [Xilinx Support web page](#) contains key resources such as product documentation, release notes, answer records, information about known issues, and links for obtaining further product support.

### Documentation

This product guide is the main document associated with the RXAUI core. This guide, along with documentation related to all products that aid in the design process, can be found on the [Xilinx Support web page](#) or by using the Xilinx® Documentation Navigator.

Download the Xilinx Documentation Navigator from the [Downloads page](#). For more information about this tool and the features available, open the online help after installation.

### Solution Centers

See the [Xilinx Solution Centers](#) for support on devices, software tools, and intellectual property at all stages of the design cycle. Topics include design assistance, advisories, and troubleshooting tips.

The Solution Center specific to the RXAUI core is listed below:

- [Xilinx Ethernet IP Solution Center](#)

### Answer Records

Answer Records include information about commonly encountered problems, helpful information on how to resolve these problems, and any known issues with a Xilinx product. Answer Records are created and maintained daily ensuring that users have access to the most accurate information available.

Answer Records for this core can be located by using the Search Support box on the main [Xilinx support web page](#). To maximize your search results, use proper keywords such as

- Product name
- Tool message(s)
- Summary of the issue encountered

A filter search is available after results are returned to further target the results.

### **Master Answer Record for the RXAUI Core**

AR: [54249](#)

## **Technical Support**

Xilinx provides technical support in the [Xilinx Support web page](#) for this LogiCORE™ IP product when used as described in the product documentation. Xilinx cannot guarantee timing, functionality, or support if you do any of the following:

- Implement the solution in devices that are not defined in the documentation.
- Customize the solution beyond that allowed in the product documentation.
- Change any section of the design labeled DO NOT MODIFY.

To contact Xilinx Technical Support, navigate to the [Xilinx Support web page](#).

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## **Debug Tools**

There are many tools available to address RXAUI design issues. It is important to know which tools are useful for debugging various situations.

### **Vivado Design Suite Debug Feature**

The Vivado® Design Suite debug feature inserts logic analyzer and virtual I/O cores directly into your design. The debug feature also allows you to set trigger conditions to capture application and integrated block port signals in hardware. Captured signals can then be analyzed. This feature in the Vivado IDE is used for logic debugging and validation of a design running in Xilinx devices.

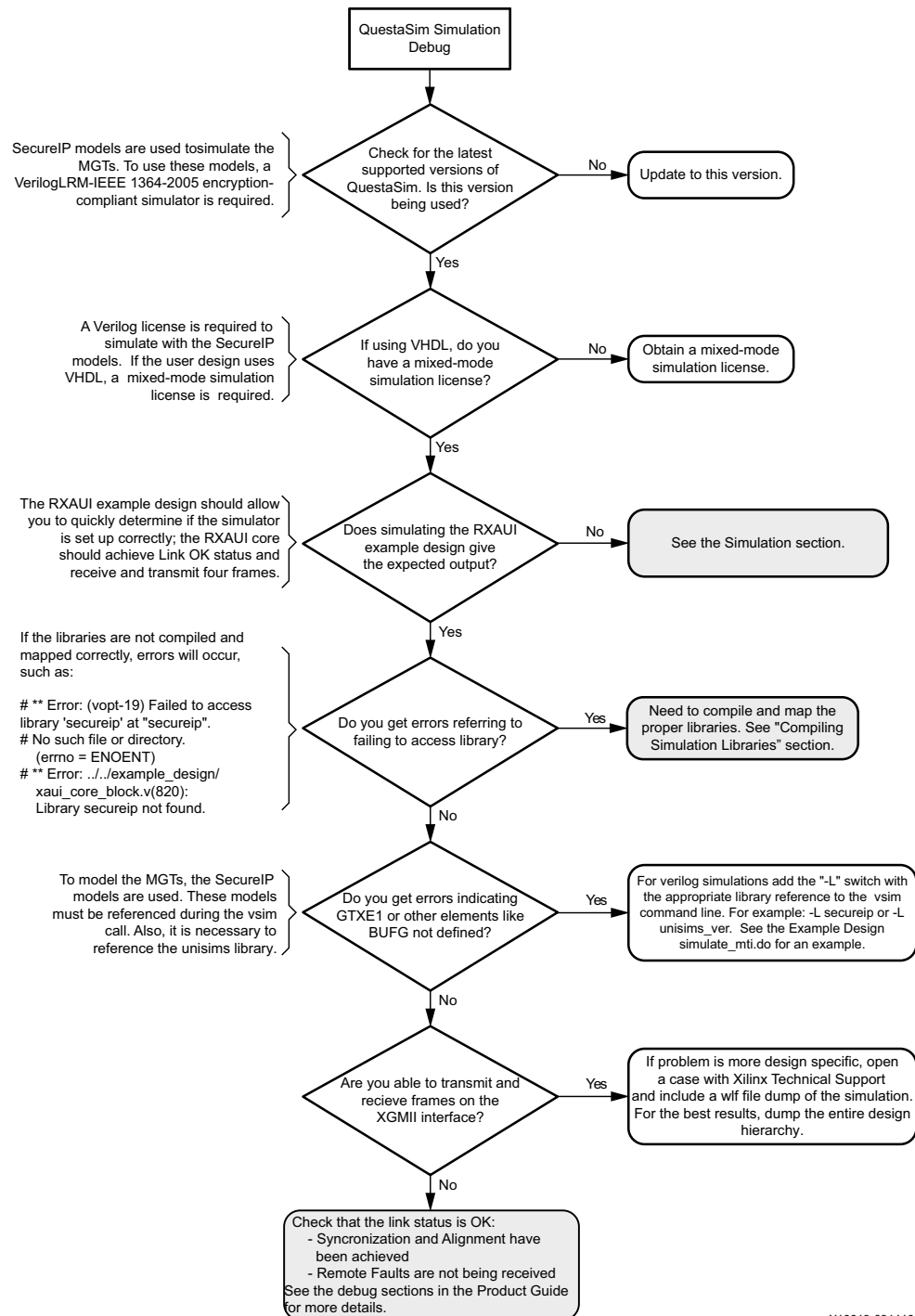
The Vivado logic analyzer is used to interact with the logic debug LogiCORE IP cores, including:

- ILA 2.0 (and later versions)
- VIO 2.0 (and later versions)

See the *Vivado Design Suite User Guide, Programming and Debugging* (UG908) [\[Ref 12\]](#).

# Simulation Debug

The simulation debug flow for QuestaSim is shown in Figure C-1. A similar approach can be used with other simulators.



X13619-091416

Figure C-1: QuestaSim Debug Flow Diagram

## Compiling Simulation Libraries

To run simulation with third-party simulators, it is necessary to compile the Xilinx Simulation Libraries. For full details on how to perform this, see Appendix B of the *Vivado Design Suite User Guide, Logic Simulation* (UG900) [Ref 9].

If the debug suggestions listed previously do not resolve the issue, open a support case. To contact Xilinx Technical Support, navigate to the [Xilinx Support web page](#).

To discuss possible solutions, use the Xilinx User Community: [forums.xilinx.com/xlnx/](https://forums.xilinx.com/xlnx/)

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## Hardware Debug

Hardware issues can range from link bring-up to problems seen after hours of testing. This section provides debug steps for common issues. The Vivado Analyzer tool is a valuable resource to use in hardware debug. The signal names mentioned in the following individual sections can be probed using the Vivado Analyzer tool for debugging the specific problems. Many of these common issues can also be applied to debugging design simulations.

### General Checks

Ensure that all the timing constraints for the core were met during Place and Route.

- Does it work in timing simulation? If problems are seen in hardware but not in timing simulation, this could indicate a PCB issue.
- Ensure that all clock sources are clean. If using DCMs in the design, ensure that all DCMs have obtained lock by monitoring the LOCKED port.

### Monitoring the RXAUI Core with Vivado Design Suite Debug Feature

- A debug port is also provided so it can connect to external logic for debug (for example, processor monitoring). This port contains transceiver and core debug information.
- XGMII signals and signals between RXAUI core and the transceiver can be added to monitor data transmitted and received. See [Table 2-1, page 9](#) and [Table 2-5, page 10](#) for a list of signal names.
- Status signals added to check status of link: `STATUS_VECTOR[7:0]`, `ALIGN_STATUS`, `SYNC_STATUS`, and Debug port Bits[5:0].
- To interpret control codes in on the XGMII interface or the interface to the transceiver, see [Table C-1](#) and [Table C-2](#).

- An Idle (0x07) on the XGMII interface is encoded to be a randomized sequence of /K/ (Sync), /R/ (Skip), /A/(Align) codes on the RXAUI interface. For details on this encoding, see the IEEE 802.3-2012 specification (section 48.2.4.2) for more details.

Table C-1: XGMII Control Codes

TXC	TXD	Description
0	0x00 through 0xFF	Normal data transmission
1	0x07	Idle
1	0x9C	Sequence
1	0xFB	Start
1	0xFD	Terminate
1	0xFE	Error

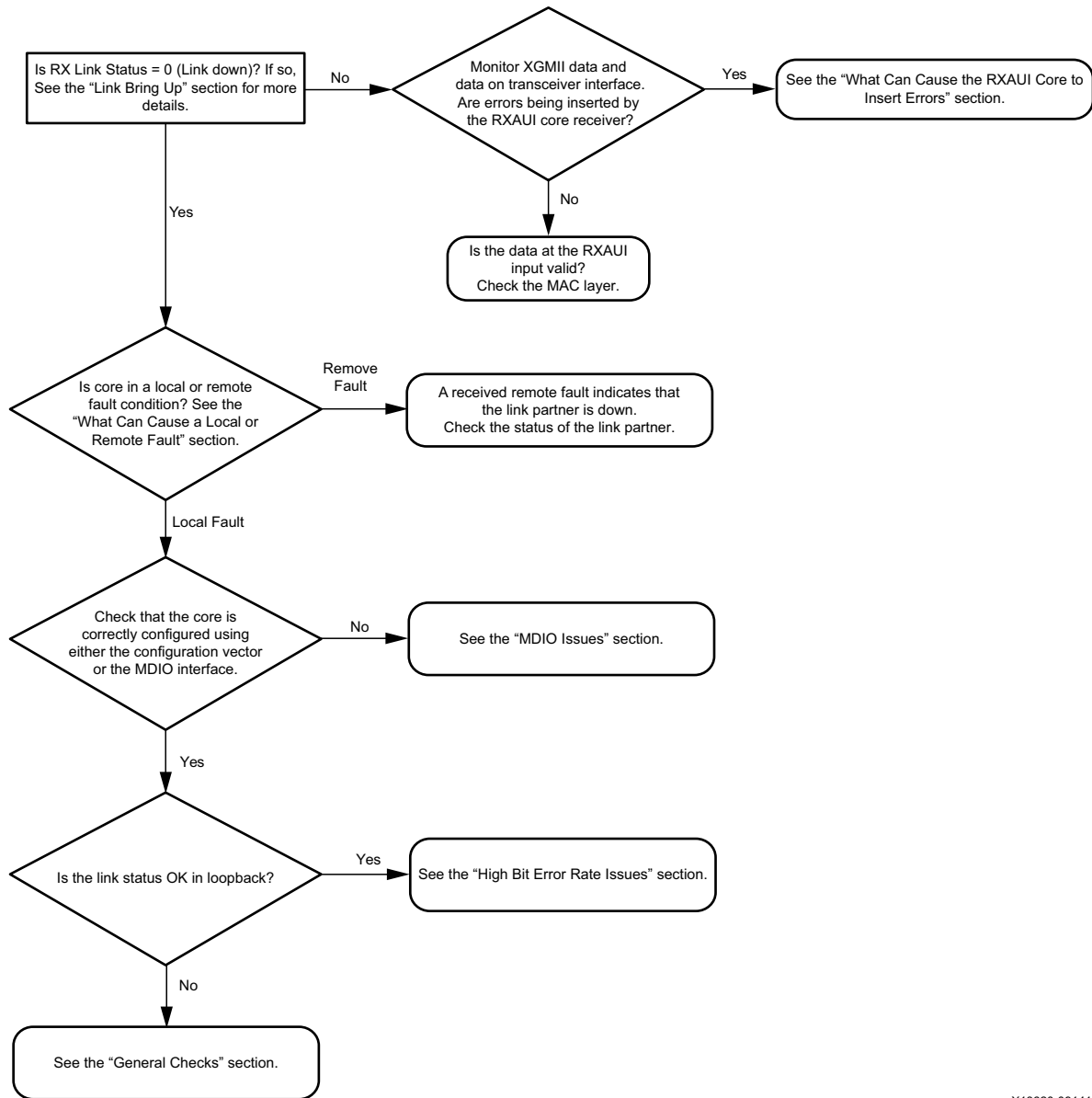
Table C-2: RXAUI Control Codes

Codegroup	8-bit Value	Description
Dxx.y	0xXX	Normal data transmission
K28.5	0xBC	/K/ (Sync)
K28.0	0x1C	/R/ (Skip)
K28.3	0x7C	/A/ (Align)
K28.4	0x9C	/Q/ (Sequence)
K27.7	0xFB	/S/ (Start)
K29.7	0xFD	/T/ (Terminate)
K30.7	0xFE	/E/ (Error)

## Issues with Data Reception or Transmission

Issues with data reception or transmission can be caused by a wide range of factors. Following is a flow diagram of steps to debug the issue. Each of the steps are discussed in more detail in the following sections.





X13620-091416

Figure C-2: Flow Diagram for Debugging Problems with Data Reception or Transmission

## What Can Cause a Local or Remote Fault?

Local Fault and Remote Fault codes both start with the sequence TXD/RXD = 0x9C, TXC/RXC = 1 in XGMII lane 0. Fault conditions can also be detected by looking at the status vector or MDIO registers. The Local Fault and Link Status are defined as latching error indicators by the IEEE specification. This means that the Local Fault and Link Status bits in the status vector or MDIO registers must be cleared with the Reset Local Fault bits and Link Status bits in the Configuration vector or MDIO registers.

## **Local Fault**

The receiver outputs a local fault when the receiver is not up and operational. This RX local fault is also indicated in the status and MDIO registers. The most likely causes for an RX local fault are:

- The transceiver has not locked or the receiver is being reset.
- At least one of the lanes is not synchronized – `SYNC_STATUS`
- The lanes are not properly aligned – `ALIGN_STATUS`

**Note:** The `SYNC_STATUS` and `ALIGN_STATUS` signals are not latching.

A TX local fault is indicated in the status and MDIO registers when the transceiver transmitter is in reset or has not yet completed any other initialization or synchronization procedures needed.

## **Remote Fault**

Remote faults are only generated in the MAC reconciliation layer in response to a Local Fault message. When the receiver receives a remote fault, this means that the link partner is in a local fault condition.

When the MAC reconciliation layer receives a remote fault, it silently drops any data being transmitted and instead transmit IDLEs to help the link partner resolve its local fault condition. When the MAC reconciliation layer receives a local fault, it silently drops any data being transmitted and instead transmit a remote fault to inform the link partner that it is in a fault condition. Be aware that the Xilinx 10GEMAC core has an option to disable remote fault transmission.

## **Link Bring Up**

The following link initialization stages describe a possible scenario of the Link coming up between device A and device B.

### **Stage 1: Device A Powered Up, but Device B Powered Down**

- Device A is powered up and reset.
- Device B powered down
- Device A detects a fault because there is no signal received. The Device A RXAUI core indicates an RX local fault.
- The Device A MAC reconciliation layer receives the local fault. This triggers the MAC reconciliation layer to silently drop any data being transmitted and instead transmit a remote fault.
- RX Link Status = 0 (link down) in Device A

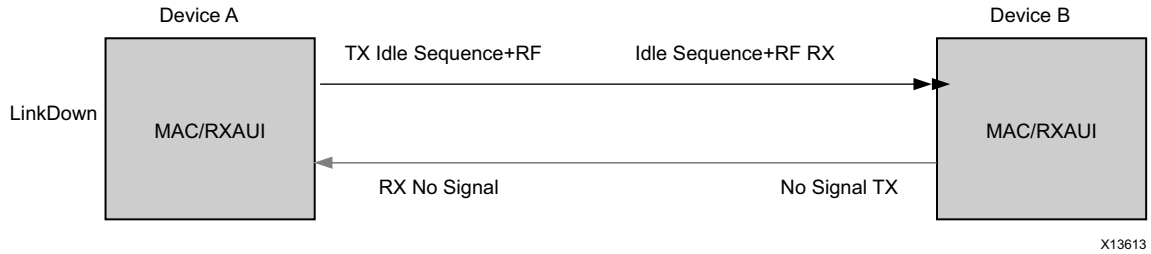


Figure C-3: Device A Powered Up, but Device B Powered Down

### Stage 2: Device B Powers Up and Resets

- Device B Powers Up and Resets.
- Device B RXAUI completes Synchronization and Alignment.
- Device A has not synchronized and aligned yet. It continues to send remote faults.
- Device B RXAUI passes received remote fault to MAC.
- Device B MAC reconciliation layer receives the remote fault. It silently drops any data being transmitted and instead transmits IDLEs.
- Link Status = 0 (link down) in both A and B.

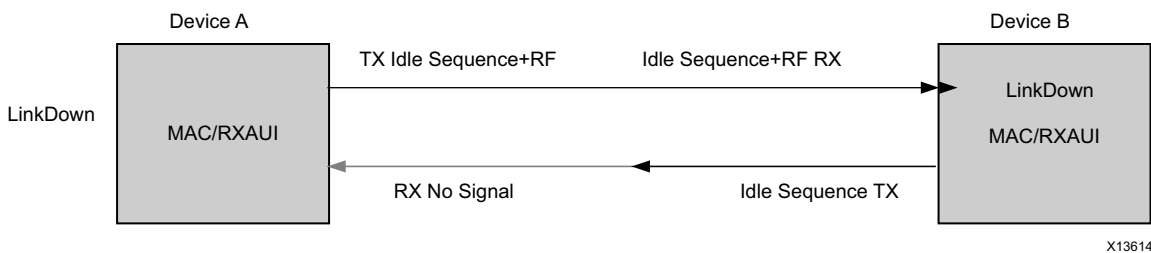


Figure C-4: Device B Powers Up and Resets

### Stage 3: Device A Receives Idle Sequence

- Device A RXAUI RX detects idles, synchronizes and aligns.
- Device A reconciliation layer stops dropping frames at the output of the MAC transmitter and stops sending remote faults to Device B.
- Device A Link Status = 1 (Link Up)
- After Device B stops receiving the remote faults, normal operation starts.

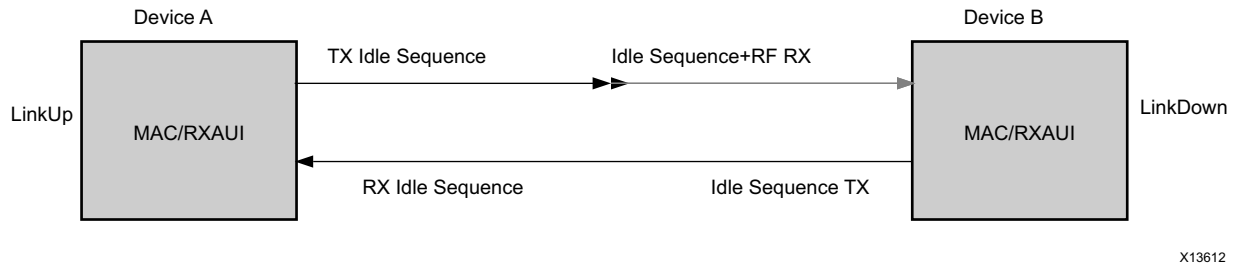


Figure C-5: Device A Receives Idle Sequence

### Stage 4: Normal Operation

In Stage 4 shown in Figure C-6, Device A and Device B have both powered up and been reset. The link status is 1 (link up) in both A and B and in both the MAC can transmit frames successfully.

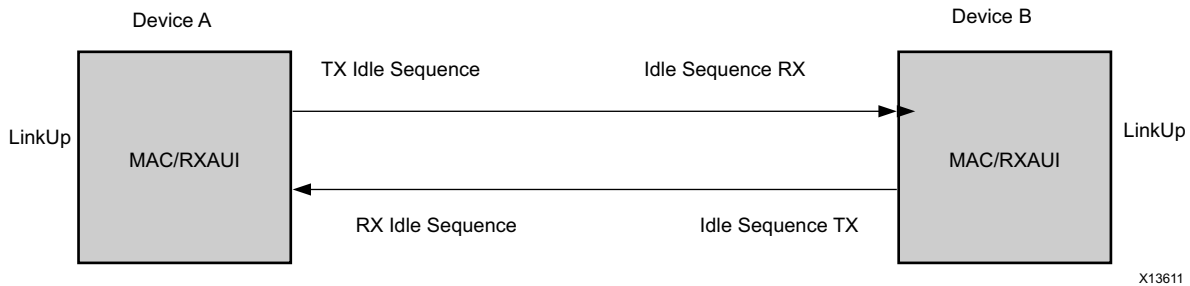


Figure C-6: Normal Operation

## What Can Cause Synchronization and Alignment to Fail?

Synchronization (`SYNC_STATUS`) occurs when each respective XAUI logical lane receiver is synchronized to byte boundaries. Alignment (`ALIGN_STATUS`) occurs when the RXAUI receiver is aligned across all four logical XAUI lanes.

Following are suggestions for debugging loss of Synchronization and Alignment:

- Monitor the state of the `SIGNAL_DETECT[1:0]` input to the core. This should either be:
  - Connected to an optical module to detect the presence of light. Logic 1 indicates that the optical module is correctly detecting light; logic 0 indicates a fault. Therefore, ensure that this is driven with the correct polarity.
  - Tied to logic 1 (if not connected to an optical module).

**Note:** When `signal_detect` is set to logic 0, this forces the receiver synchronization state machine of the core to remain in the loss of sync state.

- Loss of Synchronization can happen when invalid characters are received.

- Loss of Alignment can happen when invalid characters are seen or if an /A/ code is not seen in all four XAUI logical lanes at the same time.
- See the section, [High Bit Error Rate Issues](#).

### ***Transceiver Specific***

- Ensure that the polarities of the TXN/TXP and RXN/RXP lines are not reversed. If they are, these can be fixed by using the TXPOLARITY and RXPOLARITY ports of the transceiver.
- Check that the transceiver is not being held in reset or still be initialized by monitoring the `mgt_tx_reset`, `mgt_rx_reset`, and `mgt_rxlock` input signals to the RXAUI core. The `mgt_rx_reset` signal is also asserted when there is an RX buffer error. An RX buffer error means that the Elastic Buffer in the receiver path of the transceiver is either under or overflowing. This indicates a clock correction issue caused by differences between the transmitting and receiving ends. Check all clock management circuitry and clock frequencies applied to the core and to the transceiver.

## **What Can Cause the RXAUI Core to Insert Errors?**

On the receive path the RXAUI core inserts errors `RXD = FE`, `RXC = 1`, when disparity errors or invalid data are received or if the received interframe gap (IFG) is too small.

### ***Disparity Errors or Invalid Data***

Disparity Errors or Invalid data can be checked for by monitoring the `mgt_codevalid` input to the RXAUI core.

### ***Small IFG***

The RXAUI core inserts error codes into the Received XGMII data stream, `RXD`, when there are three or fewer IDLE characters (0x07) between frames. The error code (0xFE) precedes the frame "Terminate" delimiter (0xFD).

The IEEE 802.3-2012 specification (Section 46.2.1) requires a minimum interframe gap of five octets on the receive side. This includes the preceding frame Terminate control character and all Idles up to and immediately preceding the following frame Start control character. Because three (or fewer) Idles and one Terminate character are less than the required five octets, this would not meet the specification; therefore, the RXAUI core is expected to signal an error in this manner if the received frame does not meet the specification.

## High Bit Error Rate Issues

### *Symptoms*

If the link comes up but then goes down again or never comes up following a reset, the most likely cause for a RX Local Fault is a Bit Error Rate (BER) that is too high. A high BER causes incorrect data to be received, which leads to the lanes losing synchronization or alignment.

### *Debugging*

Compare the issue across several devices or PCBs to ensure that the issue is not a one-off case.

- Try using an alternative link partner or test equipment and then compare results.
- Try putting the core into loopback (both by placing the core into internal loopback, and by looping back the optical cable) and compare the behavior. The core should always be capable of gaining synchronization and alignment when looping back with itself from transmitter to receiver so direct comparisons can be made. If the core exhibits correct operation when placed into internal loopback, but not when loopback is performed using an optical cable, this can indicate a faulty optical module or a PCB issue.
- Try swapping the optical module on a misperforming device and repeat the tests.

### *Transceiver Specific Checks*

- Monitor the `MGT_CODEVALID[7:0]` input to the RXAUI core by triggering on it using the Vivado Analyzer tool. This input is a combination of the transceiver RX disparity error and RX not in table error outputs.
- These signals should not be asserted over the duration of a few seconds, minutes, or even hours. If they are frequently asserted, it can indicate an issue with the transceiver.
- Place the transceiver into parallel or serial near-end loopback.
  - If correct operation is seen in the transceiver serial loopback, but not when loopback is performed using an optical cable, it can indicate a faulty optical module.
  - If the core exhibits correct operation in the transceiver parallel loopback but not in serial loopback, this can indicate a transceiver issue.
- A mild form of bit error rate can be solved by adjusting the transmitter Pre-Emphasis and Differential Swing Control attributes of the transceiver.

## MDIO Issues

See [MDIO Interface, page 71](#) for detailed information about performing MDIO transactions.

Things to check for:

- Ensure that the MDIO is driven properly. Check that the MDC clock is running and that the frequency is 2.5 MHz or less.
- Ensure that the RXAUI core is not held in reset.
- Read from a Configuration register that does not have all 0s as a default. If all 0s are read back, the read was unsuccessful. Check that the `PRTAD` field placed into the MDIO frame matches the value placed on the `PRTAD[4:0]` port of the RXAUI core.
- Verify in simulation and/or a Vivado Analyzer capture that the waveform is correct for accessing the host interface for a MDIO read/write.

If the debug suggestions listed previously do not resolve the issue, open a support case. To contact Xilinx Technical Support, navigate to the [Xilinx Support web page](#).

To discuss possible solutions, use the Xilinx User Community: [forums.xilinx.com/xlnx/](https://forums.xilinx.com/xlnx/)

# Additional Resources and Legal Notices

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## Xilinx Resources

For support resources such as Answers, Documentation, Downloads, and Forums, see [Xilinx Support](#).

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## References

These documents provide supplemental material useful with this product guide:

1. Dune Networks DN-DS-RXAUI-Spec v1.0, RXAUI - Reduced Pin XAUI
2. *7 Series FPGAs GTX/GTH Transceivers User Guide* ([UG476](#))
3. *7 Series FPGAs GTP Transceivers User Guide* ([UG482](#))
4. *UltraScale Architecture GTH Transceivers User Guide* ([UG576](#))
5. *UltraScale Architecture GTY Transceivers User Guide* ([UG578](#))
6. *Vivado Design Suite User Guide: Designing IP Subsystems using IP Integrator* ([UG994](#))
7. *Vivado Design Suite User Guide, Designing with IP* ([UG896](#))
8. *Vivado Design Suite User Guide: Getting Started* ([UG910](#))
9. *Vivado Design Suite User Guide, Logic Simulation* ([UG900](#))
10. *ISE to Vivado Design Suite Migration Guide* ([UG911](#))
11. *UltraScale Architecture Migration Methodology Guide* ([UG1026](#))
12. *Vivado Design Suite User Guide, Programming and Debugging* ([UG908](#))
13. IEEE Std. 802.3-2008, Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications



## Revision History

The following table shows the revision history for this document.

Date	Version	Revision
10/05/2016	4.3	<ul style="list-style-type: none"> <li>Performance and Resource Utilization moved to the web.</li> <li>Minor doc updates.</li> </ul>
11/18/2015	4.3	<ul style="list-style-type: none"> <li>Added UltraScale+ support.</li> </ul>
04/01/2015	4.3	<ul style="list-style-type: none"> <li>Updated to add support for UltraScale GTYE3 transceivers.</li> <li>Added clock domain information to the Port Descriptions.</li> <li>Added new GUI Customization options for UltraScale devices, including transceiver selection and reference clock frequency selection.</li> <li>Added new transceiver Control and Status ports for gt_txinhibit and gt_pcsrsvdin.</li> </ul>
11/19/2014	4.2	<ul style="list-style-type: none"> <li>Updated IEEE Std. 802.3-2012.</li> <li>Updated Register Bit Definitions.</li> </ul>
06/04/2014	4.2	<ul style="list-style-type: none"> <li>Added User Parameters to Design Flow Steps chapter.</li> <li>Added Device Migration to Migrating and Upgrading appendix.</li> </ul>
04/02/2014	4.2	<ul style="list-style-type: none"> <li>Replaced "Kintex UltraScale" with UltraScale "architecture".</li> <li>Added missing port for Artix-7 designs with share logic in core.</li> </ul>
12/18/2013	4.1	<ul style="list-style-type: none"> <li>Added UltraScale™ architecture support.</li> <li>Added GTP Clocking Ports table.</li> <li>Added Clocking Ports tables for UltraScale architecture.</li> <li>Updated Example Design chapter.</li> <li>Updated Migrating and Upgrading appendix.</li> </ul>
10/02/2013	4.0	<ul style="list-style-type: none"> <li>Revision number advanced to 4.0 to align with core version number.</li> <li>Added 'Shared logic' core option throughout the document.</li> <li>Updated Ports and Port description tables throughout <a href="#">Chapter 2</a>.</li> <li>Added <a href="#">Changing the clk156 Clock Buffer for 7 Series and Zynq-7000 Devices</a>.</li> <li>Updated <a href="#">Multiple Core Instances</a>.</li> <li>Updated <a href="#">Constraining the Core</a>.</li> <li>Updated <a href="#">Chapter 5, Example Design</a>.</li> <li>Added <a href="#">Chapter 6, Test Bench</a>.</li> <li>Added <a href="#">Appendix B, Migrating and Upgrading</a>.</li> </ul>

Date	Version	Revision
03/20/2013	1.1	<ul style="list-style-type: none"> <li>• Updated to v3.0 for Vivado Design Suite only and removed ISE.</li> <li>• Updated Fig. 1-2 Implementation of Dune Networks RXAUI Core.</li> <li>• Updated Table 2-5 Transceiver Interface Ports.</li> <li>• Updated Table 2-7 Configuration and Status Ports.</li> <li>• Added Tables 2-11 Clock and Resets Option Selected to 2-13 GTP Clocking Ports.</li> <li>• Updated SIGNAL_DETECT descriptions in Table 2-25 10G PMD Signal Receive OK Register Bit Definitions.</li> <li>• Added new Clocking and Reset Signals and Module to Debug Interface sections.</li> <li>• Updated Alignment Status and Synchronization Status Ports table.</li> <li>• Updated Fig. 3-1 7 Series GTX transceivers to Fig. 3-3 7 Series GTP transceivers.</li> <li>• Updated Fig. 4-1 RXAUI Main Screen.</li> <li>• Updated Constraining the Core section.</li> <li>• Updated Fig. 6-1 RXAUI Example Design and Test Bench and added Fig. 6-2.</li> <li>• Updated to new Debug section.</li> <li>• Updated to QuestaSim.</li> </ul>
10/16/2012	1.0	Initial Xilinx release. This Product Guide is derived from DS740 and UG693. Vivado Design Suite and Artix-7 support added.

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