

# Quad Serial Gigabit Media Independent v3.4

## *LogiCORE IP Product Guide*

**Vivado Design Suite**

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## Introduction

The LogiCORE™ Quad Serial Gigabit Media Independent Interface (QSGMII) core provides a flexible solution for combining four Serial Gigabit Media Independent Interfaces (SGMII) into one 5 Gigabits per second (Gb/s) interface, to significantly reduce the number of inputs/ outputs (I/Os). This core supports *Cisco QSGMII Specification Version 1.2* (EDCS-540123) [Ref 1].

## Features

- Integrated transceiver interface using a Zynq®-7000 All Programmable SoC, Virtex®-7, and Kintex®-7 device GTX transceiver
- Integrated transceiver interface using UltraScale+™ families, UltraScale™ architecture, and Virtex-7 FPGA GTH transceiver
- Integrated transceiver interface using Artix®-7 FPGA GTP transceiver
- Implements SGMII Adaptation to support 10/100/1000 operation for each port
- Transmitters of all ports transmit only /I1/ Idle ordered set
- Lane alignment based on K28.1 character detection
- Implements QSGMII K28.5 swapper on Port 0 transmit path
- Implements QSGMII K28.1 swapper on Port 0 receive path
- Implements receive link synchronization state machine
- Programmable Decoder running disparity checking for each port
- Supports full duplex mode only

LogiCORE IP Facts Table	
<b>Core Specifics</b>	
Supported Device Family <sup>(1)</sup>	UltraScale+, UltraScale, Zynq-7000, Artix-7, Kintex-7, Virtex-7
Supported User Interfaces	GMII/MII
Resources	See <a href="#">Performance and Resource Utilization</a> web page.
<b>Provided with Core</b>	
Design Files	Encrypted RTL
Example Design	VHDL and Verilog
Test Bench	Demonstration Test Bench in VHDL and Verilog
Constraints File	Xilinx Design Constraints (XDC)
Simulation Model	Verilog and VHDL
Supported S/W Drivers	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 list 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 QSGMII IP core is designed to reduce significantly the number of signals that are needed between multi port 10/100/1000 PHYs and Ethernet MAC. QSGMII needs two data signals, each operating at 5 Gb/s, to connect four instances of PHYs and Ethernet MAC.

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### System Overview

The QSGMII core provides the functionality to implement the sublayers as specified by the Cisco QSGMII specification.

The QSGMII core interfaces to a device-specific transceiver. The transceiver provides some of the PCS functionality, such as 8B/10B encoding/decoding, Physical Medium Attachment (PMA) Serializer/Deserializer (SerDes), and clock recovery. [Figure 1-1](#) illustrates the remaining PCS sublayer functionality and also shows the major functional blocks of the core.

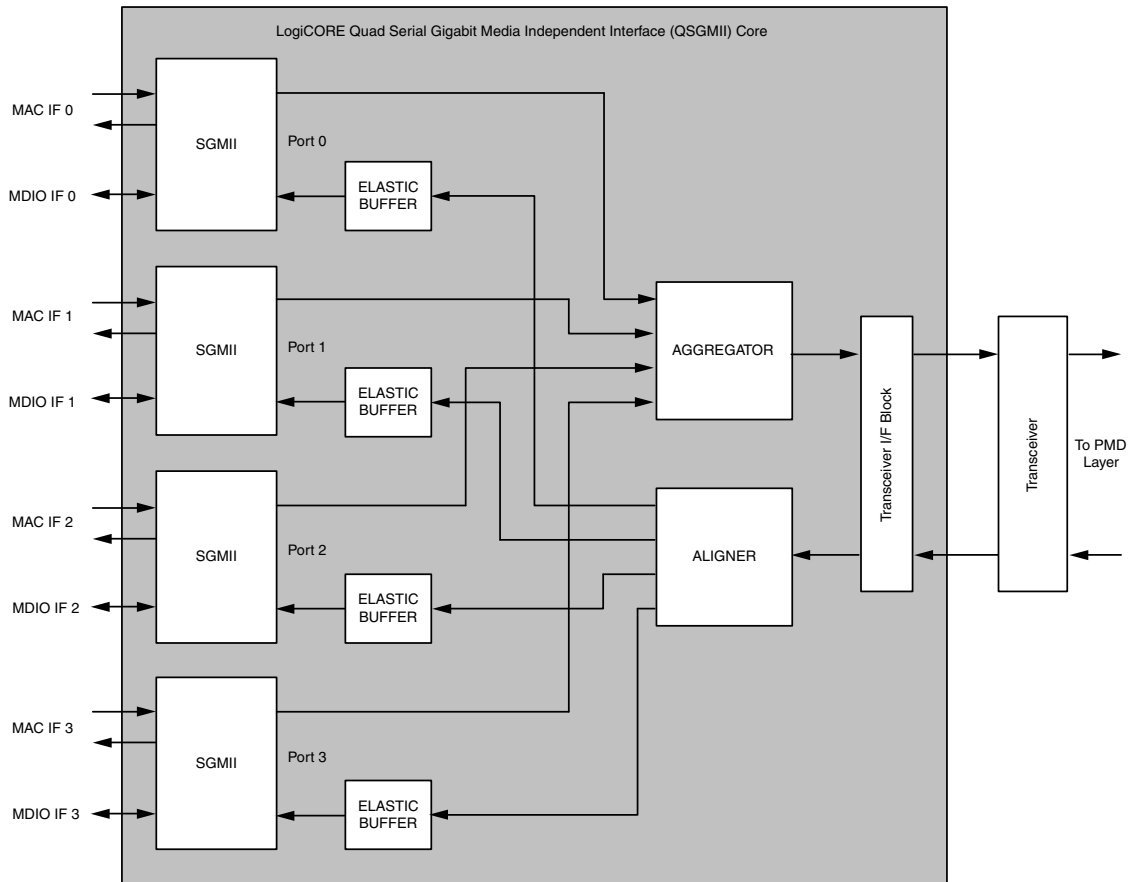


Figure 1-1: QSGMII System Overview

## SGMII

Figure 1-2 illustrates the sub-blocks of the SGMII module.

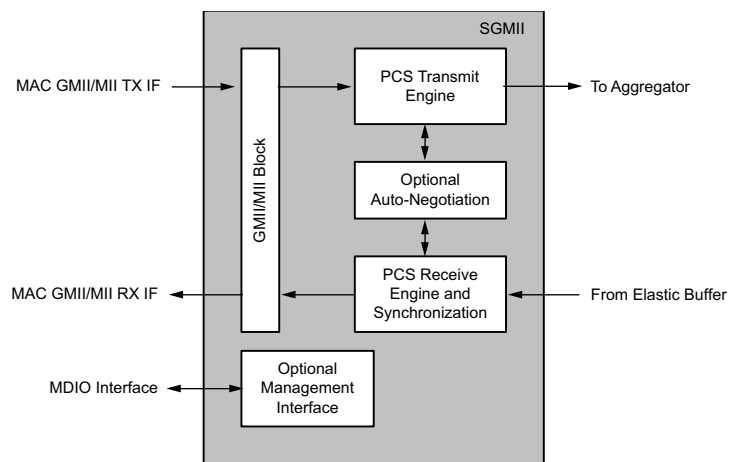


Figure 1-2: Functional Diagram of SGMII Block

## **GMII/MII Block**

A client-side GMII is provided with the core, which can be used as an internal interface for connection to an embedded Media Access Controller (MAC) or other custom logic in MAC mode. In PHY mode, the GMII/MII can be routed to device Input Output Blocks (IOBs) to provide an external (off-device) GMII/MII.

Virtex<sup>®</sup>-7 devices support GMII at 3.3V or lower only in certain parts and packages. See the [Virtex-7 Family home page](#). Zynq<sup>®</sup>-7000 All Programmable SoC, Kintex<sup>®</sup>-7, and Artix<sup>®</sup>-7 devices support GMII at 3.3V or lower.

## **PCS Transmit Engine**

The Physical Coding Sublayer (PCS) transmit engine converts the GMII data octets into a sequence of ordered sets by implementing the state diagrams of *IEEE 802.3-2008 Specification* [Ref 2] (Figures 36-5 and 36-6). The transmit engine transmits only /I1/ characters instead of /I2/, as described in the QSGMII specification.

## **PCS Receive Engine and Synchronization**

The synchronization process implements the state diagram of *IEEE 802.3-2008* (Figure 36-9). The PCS receive engine converts the sequence of ordered sets to GMII data octets by implementing the state diagrams of *IEEE 802.3-2008 Specification* [Ref 2] (Figures 36-7a and 36-7b). This module can be programmed to optionally consider disparity. Disparity checking is disabled by default.

## **Optional Auto-Negotiation Block**

Clause 37 in the *IEEE 802.3-2008 Specification* [Ref 2] describes the Auto-Negotiation function that allows a device to advertise the modes of operation that it supports to a device at the remote end of a link segment (link partner), and to detect corresponding operational modes that the link partner might be advertising.

Auto-Negotiation is controlled and monitored through the PCS Management registers.

## **Optional PCS Management Registers**

Configuration and status of the core, including access to and from the optional Auto-Negotiation function, uses the Management registers defined in clause 37 of the *IEEE 802.3-2008 Specification* [Ref 2]. These registers are accessed through the serial Management Data Input/Output Interface (MDIO), defined in clause 22 of the *IEEE 802.3-2008 Specification* [Ref 2], as if it were an externally connected PHY.

An additional configuration vector and status signal interface is provided to configure Base Control register (Register 0) and Auto-Negotiation Ability Advertisement register (Register 4).

## Aggregator

The Aggregator implements a portion of a modified transmit path diagram (Figure 1 of the QSGMII v1.2 specification). This module receives data and control from each instance of the SGMII module which is aggregated to 32-bit data and 4-bit control and transferred to Transceiver Interface block. The Aggregator also incorporates the K28.5 swapping function on port 0 that assists in port matching at the peer receiver end.

## Aligner

The Aligner receives 32 bits of data from the transceiver interface. Port 0 data can be received on any lane, so a search for the K28.1 character is done on all the lanes to start lane alignment. After a match for K28.1 is found in the octet boundary in the 32-bit data, that octet boundary becomes the start of arbitration and the octet assigned to port 0. The next octet is assigned to port 1 and so on. This module also swaps any K28.1 character received on port 0 with the K28.5 character.

## Transceiver Interface Block

The Transceiver Interface Block enables the core to connect to UltraScale+™ families, UltraScale™ architecture, Zynq-7000 AP SoC, Virtex-7, Kintex-7, or Artix-7 device serial transceiver.

## Elastic Buffer

An Elastic Buffer is instantiated on each port to perform clock correction. The clock correction involves additions and removal of /I1/ characters if disparity is ignored or /I2/ if the disparity is considered. This buffer is 128 locations deep.

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## Feature Summary

- The core has two modes of operation.
  - **Media Access Controller (MAC)** mode to connect to a customized MAC or Xilinx® Tri-Mode Ethernet MAC LogiCORE™ IP operating in Internal Mode. See [QSGMII MAC](#) in the Applications section.
  - **Physical-side interface (PHY)** mode to connect to an external PHY through Gigabit Media Independent Interface/Media Independent Interface (GMII/MII). See [QSGMII PHY](#) in the Application section.
- Each port configured and monitored through independent a serial MDIO interface, which can optionally be omitted from the core. An additional configuration vector interface is provided that can be used to program registers 0 and 4 over and above the MDIO interface.



- Supports Auto-Negotiation according to *IEEE 802.3-2008* Clause 37 on each port for information exchange with a link partner, which can optionally be omitted from the core.
- Integrated transceiver interface using a Zynq-7000 AP SoC, Virtex-7, and Kintex-7 device GTX transceiver.
- Integrated transceiver interface using an UltraScale+ families, UltraScale architecture, and Virtex-7 FPGA GTH transceiver.
- Integrated transceiver interface using Artix-7 FPGA GTP transceiver.
- Implements SGMII Adaptation to support 10/100/1000 operation for each port. Each port can be programmed to operate at a speed independent of other ports.
- Transmitters of all ports transmit only /I1/ Idle ordered set.
- Lane alignment based on K28.1 character detection.
- Implements QSGMII K28.5 swapper on Port 0 transmit path.
- Implements QSGMII K28.1 swapper on Port 0 receive path.
- Implements receive link synchronization state machine.
- Programmable Decoder running disparity checking for each port.
- Supports maximum frame size of 2.8 KB for 10 Mb/s, 28 KB for 100 Mb/s and 280 KB for 1 Gb/s per single lane.

**Note:** By default, the QSGMII core does not support half-duplex mode. To request this functionality, contact your local Xilinx support representative.

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## Applications

Typical applications for the QSGMII core include the following:

- [QSGMII MAC](#)
- [QSGMII PHY](#)

## QSGMII MAC

Figure 1-3 illustrates a typical application for the QSGMII core when operating in MAC mode using a device-specific transceiver to provide the serial interface.

- The device-specific transceiver is connected to an external off-the-shelf QSGMII PHY (This can be a device that supports conversion of QSGMII to 10BASE-T, 100BASE-T, or 1000BASE-T.)
- The GMII interfaces of the QGMII core are connected to multiple instances of an embedded Ethernet MAC, for example, the Xilinx Tri-Mode Ethernet MAC core.

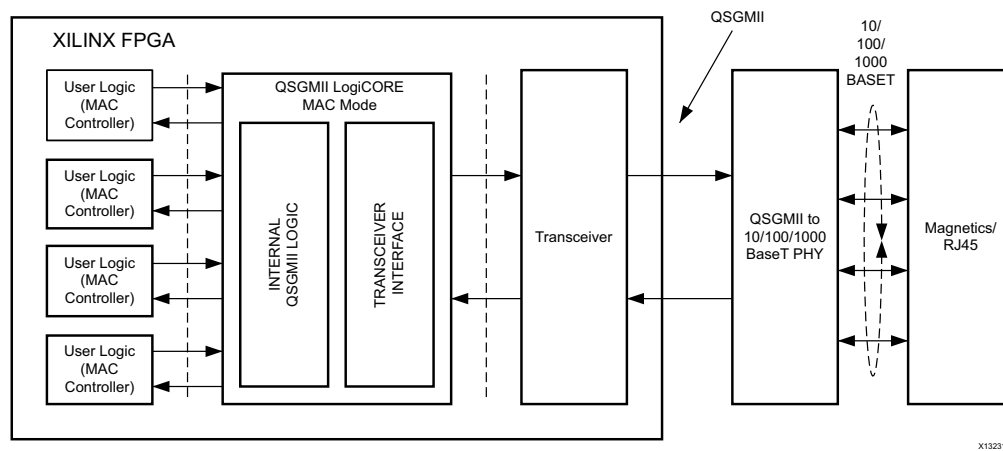


Figure 1-3: Typical Application of QSGMII in MAC Mode

## QSGMII PHY

Figure 1-4 illustrates a typical application for the QSGMII core when operating in PHY mode, using a device-specific transceiver to provide the serial interface.

- The device-specific transceiver is connected to an external off-the-shelf Ethernet MAC device that also supports QSGMII. (This can be multiple instances of tri-mode MAC providing 10/100/1000 Mb/s operation, for example, the Xilinx Tri-Mode Ethernet MAC core connected to QSGMII core in MAC mode.)
- The GMII/MII interface of QSGMII core is connected to a tri-mode PHY providing 10BASE-T, 100BASE-T, and 1000BASE-T operation.

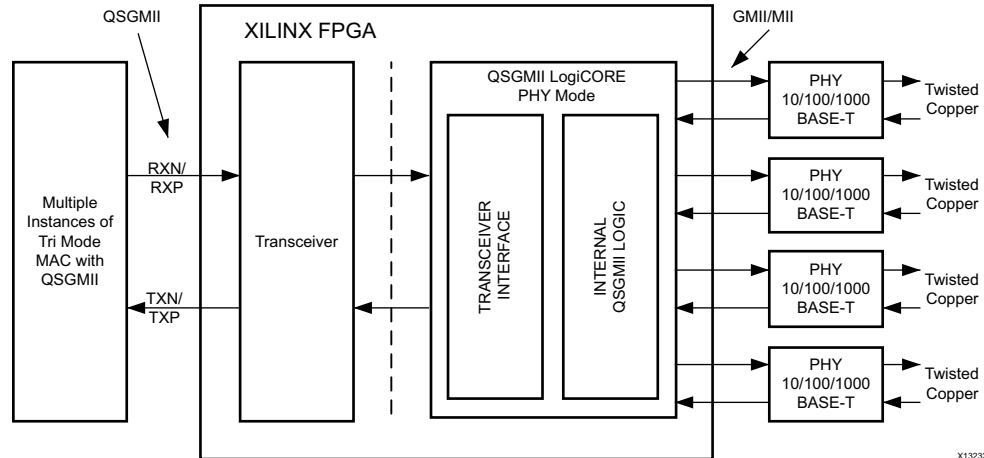


Figure 1-4: Typical Application of QSGMII in PHY Mode

## Licensing and Ordering

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

- *Ethernet Standard 802.3-2008* Clauses 22, 35, 36 and 38 [Ref 2]
  - *Cisco Serial GMII Specification* Revision 1.8 (SGMII) [Ref 3]
  - *Cisco Quad SGMII Specification* Revision 1.2 (QSGMII) [Ref 4]
- 

## Performance

### Latency

These measurements are for the core only; they do not include the latency through the UltraScale+™ families, UltraScale™ architecture, Zynq®-7000 All Programmable SoC, Virtex®-7, Kintex®-7, or Artix®-7 device transceiver, or the Transmitter Elastic Buffer added in the QSGMII core.

#### ***Transmit Path Latency***

As measured from a data octet input into `gmii_txd[7:0]` of the transmitter side GMII of SGMII on port 0 (until that data appears on `txdata[7:0]` on the serial transceiver interface), the latency through the core in the transmit direction is five clock periods of `userclk2`.

#### ***Receive Path Latency***

Receive Path Latency is variable because of an elastic buffer on each lane for clock compensation; therefore, the latency is measured from the output of the elastic buffer until the octet appears on the receiver side GMII. As measured from a data octet output from the elastic buffer until that data appears on `gmii_rxd[7:0]` of the receiver side GMII of port 0, the latency through the core in the receive direction is six clock periods of `userclk2`.

## Throughput

QSGMII Interface operates at a full line rate of 5 Gb/s.

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## Resource Utilization

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

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## Port Descriptions

### Internal Encrypted Hierarchy of the Core Level Ports

All ports in the encrypted hierarchy of the core are internal connections in FPGA logic. Un-encrypted HDL in the core and example design (delivered with the core) connect the core, where appropriate, to a device-specific transceiver, and/or add IBUFs, OBUFs, and IOB flip-flops to the external signals of the GMII/MII. IOBs are added to the remaining unconnected ports to take the example design through the Xilinx implementation software. All the ports described here indicate the pins at the in the encrypted hierarchy of the core level. The block level design instantiates the core and transceiver.

All clock management logic is placed in this example design, allowing you more flexibility in implementation (such as designs using multiple cores). This example design is provided in both VHDL and Verilog.

[Figure 2-1](#) shows the pinout for the QSGMII core using a device-specific transceiver with the optional MDIO Management and optional Auto-Negotiation.

The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."

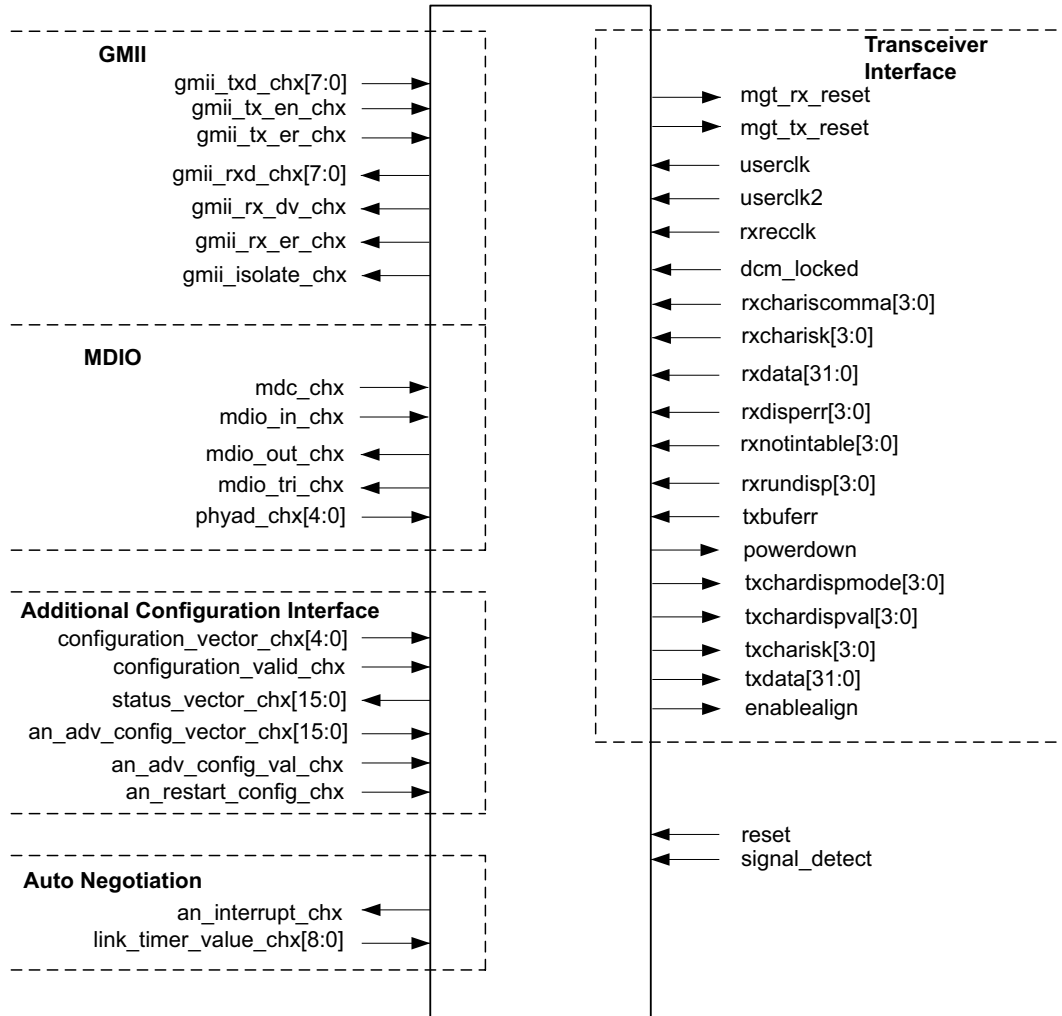
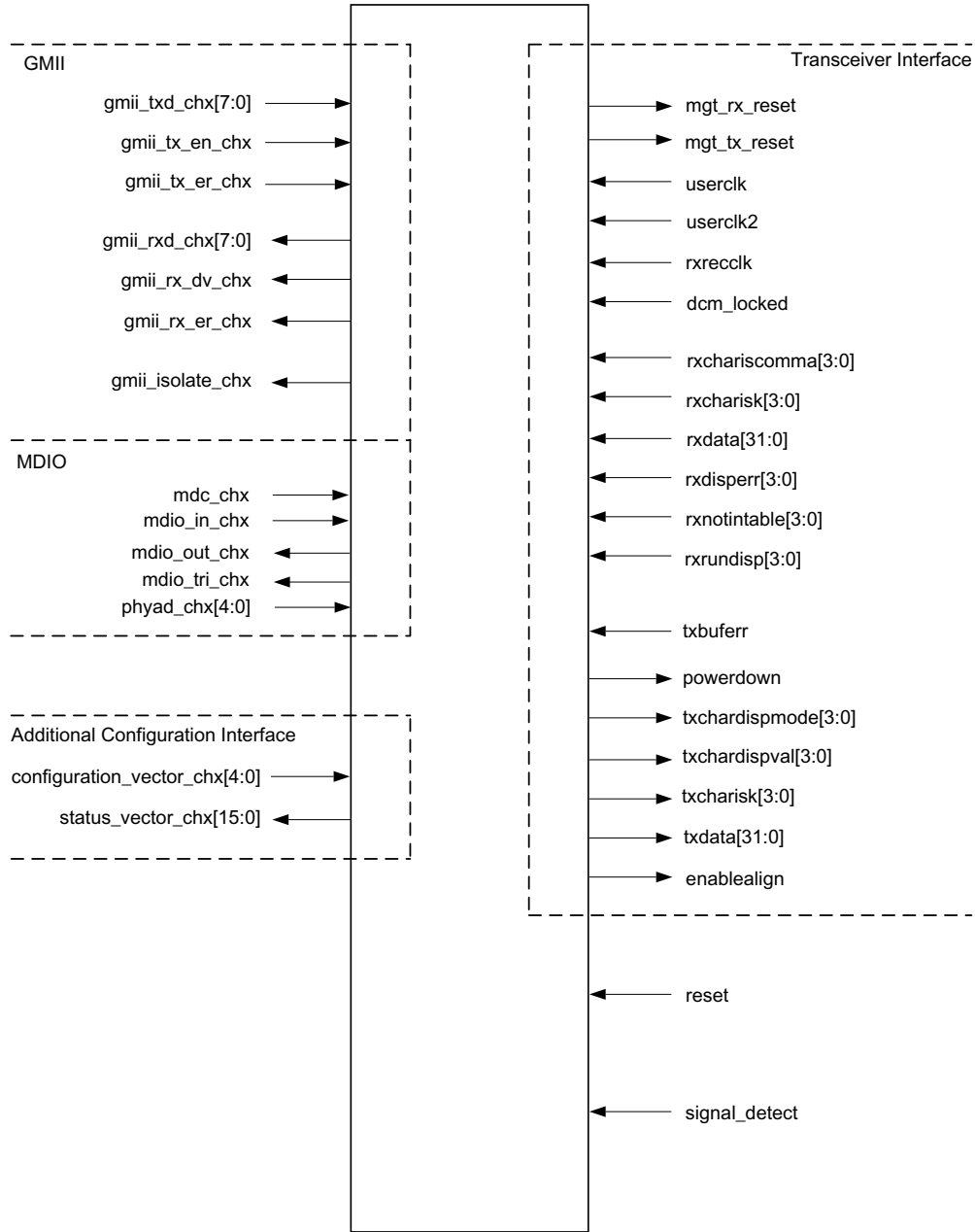


Figure 2-1: Component Pinout of QSGMII Core with Optional MDIO and Auto-Negotiation

Figure 2-2 shows the pinout for the QSGMII core using a device-specific transceiver with only the optional MDIO Management. The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."



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Figure 2-2: Component Pinout of QSGMII Core with Only Optional MDIO Management

Figure 2-3 shows the pinout for the QSGMII core using a device-specific transceiver with only the optional Auto-Negotiation.

The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."

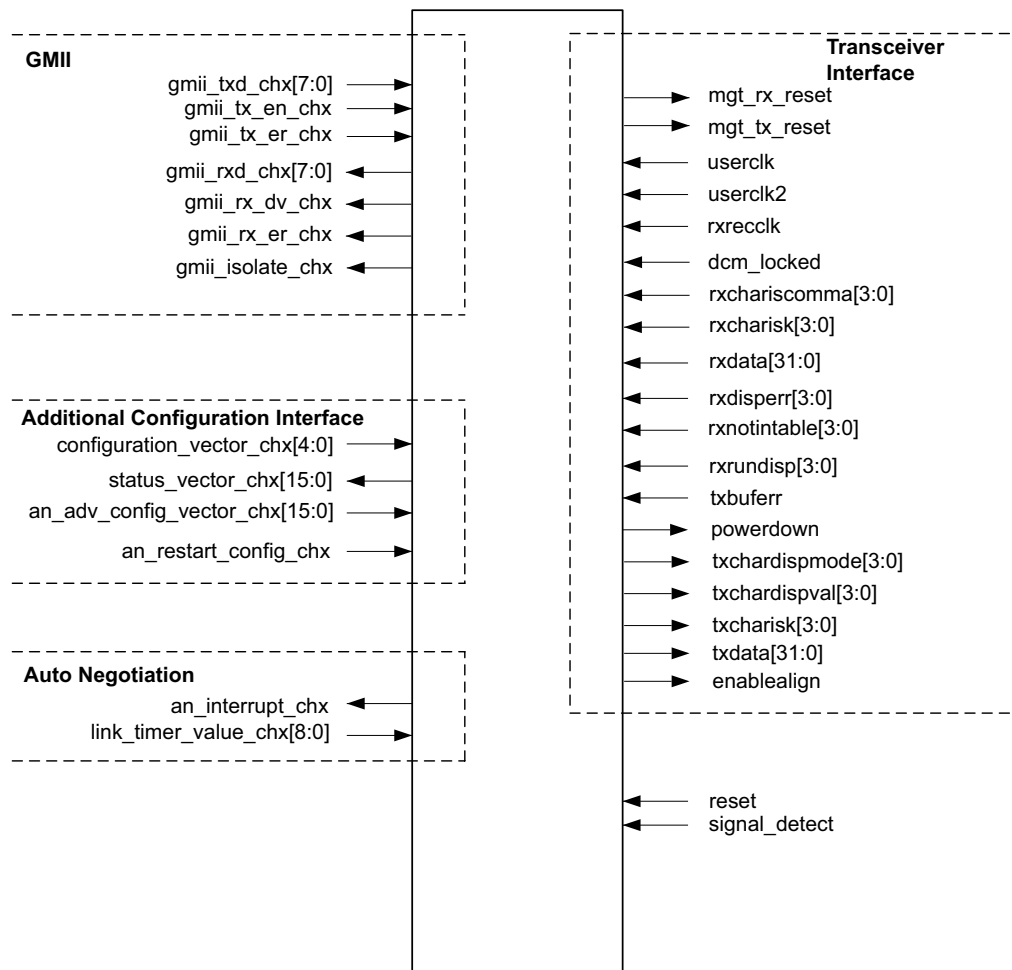


Figure 2-3: Component Pinout of QSGMII Core with Only Optional Auto-Negotiation



Figure 2-4 shows the pinout for the QSGMII core using a device-specific transceiver without optional MDIO or Auto-Negotiation.

The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."

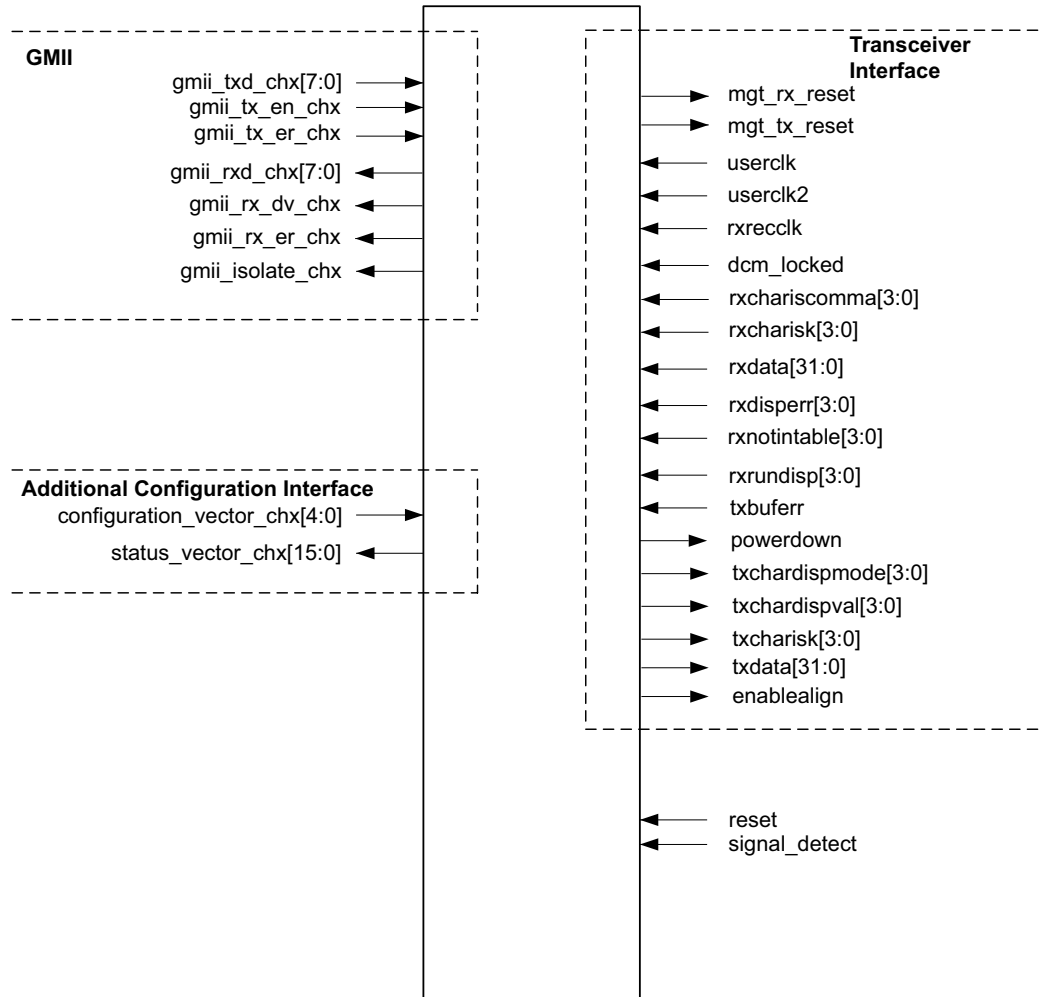


Figure 2-4: Component Pinout for QSGMII Core without Optional MDIO or Auto-Negotiation

### QSGMII Core Client Side Interface

This interface contains four groups of interfaces, with each group containing a set of the GMII interface, the optional management interface if supported and configuration vectors. MII interface, if present on the QSGMII block, is converted to a GMII type interface. The interfaces end in "chx," taking the values ch0 to ch3, indicating the port connection to the respective GMII interface.

## GMII Pinout

Table 2-1 describes the GMII-side interface signals of the core that are common to all parameterizations of the core. These are typically attached to an Ethernet MAC, either off-chip or internally integrated. The HDL block level in PHY mode of operation for seamless connection to pads in IP Canvas delivered with the core connects these signals to IOBs to provide a place-and-route example.

Table 2-1: GMII Interface Signals Pinout

Signal	Direction	Description
gmii_txd_chx[7:0] <sup>(1)</sup>	Input	GMII Transmit data from MAC
gmii_tx_en_chx <sup>(1)</sup>	Input	GMII Transmit control signal from MAC
gmii_tx_er_chx <sup>(1)</sup>	Input	GMII Transmit control signal from MAC
gmii_rxd_chx[7:0] <sup>(1)</sup>	Output	GMII Received data to MAC
gmii_rx_dv_chx <sup>(1)</sup>	Output	GMII Received control signal to MAC
gmii_rx_er_chx <sup>(1)</sup>	Output	GMII Received control signal to MAC
gmii_isolate_chx <sup>(1)</sup>	Output	IOB 3-state control for GMII Isolation. Only of use when implementing an external GMII.

### Notes:

1. These signals are synchronous to the internal 125 MHz reference clock of the core. This is userclk2.

## Common Signals

Table 2-2 describes the remaining signals common to all parameterizations of the core.

Table 2-2: Other Common Signals

Signal	Direction	Description
reset	Input	Asynchronous reset for the entire core. Active-High. Clock domain is not applicable.
signal_detect	Input	Signal direct from the Physical Medium Dependent (PMD) sublayer indicating the presence of light detected at the optical receiver. If set to 1, indicates that the optical receiver has detected light. If set to 0, this indicates the absence of light. If unused, this signal should be set to 1 to enable correct operation the core. Clock domain is not applicable.

## MDIO Management Interface Pinout (Optional)

The optional MDIO Management Interface is provided for each instance of SGMII. The "chx" suffix denotes a generic nomenclature for describing the interface. Each of the interfaces are identified with "chx" taking values from "ch0" to "ch3."

Table 2-3 describes the optional MDIO interface signals of the core that are used to access the PCS Management registers. Each of these interfaces is typically connected to the MDIO port of a MAC device, either off-chip or to an internally integrated MAC core. For more information, see [Management Registers](#).

Table 2-3: Optional MDIO Interface Pinout

Signal	Direction	Clock Domain	Description
mdc_chx	Input	NA	Management clock (<= 2.5 MHz).
mdio_in_chx <sup>(1)</sup>	Input	mdc_chx	Input data signal for communication with the instance number "x" of the MDIO controller (for example, an Ethernet MAC). Tie High if unused.
mdio_out_chx <sup>(1)</sup>	Output	mdc_chx	Output data signal for communication with the instance number "x" of the MDIO controller (for example, an Ethernet MAC).
mdio_tri_chx <sup>(1)</sup>	Output	mdc_chx	3-state control for MDIO signals. The value 0 signals that the value on mdio_out should be asserted onto the MDIO interface.
phyad_chx[4:0]	Input	NA	Physical Addresses of the PCS Management register set of each "x" instance of SGMII. It is expected that this signal is tied off to a logical value.

**Notes:**

1. These signals can be connected to a 3-state buffer to create a bidirectional mdio signal suitable for connection to an external MDIO controller (for example, an Ethernet MAC).

**Auto-Negotiation Interface Pinout (Optional)**

Table 2-4 describes the signals present when the optional Auto-Negotiation functionality is present.

Table 2-4: Optional Auto-Negotiation Interface Signal Pinout

Signal	Direction	Description
an_interrupt_chx <sup>(1)</sup>	Output	<p>When an optional management interface is present, active-High interrupt to signal the completion of an Auto-Negotiation cycle. This interrupt can be enabled/disabled and cleared by writing to the appropriate PCS Management register.</p> <p>When an optional management interface is not present, this signal just indicates the completion of the Auto-Negotiation cycle. Is reset automatically if Auto-Negotiation restarts. This bit cannot be cleared.</p>

**Notes:**

1. These signals are synchronous to the internal 125 MHz reference clock of the core. This is `userclk2` when the core is used with the device-specific transceiver.

**Additional Configuration Interface**

This interface can be used over and above the optional management interface to write into the Control register (Register 0) and the Auto-Negotiation Advertisement register (Register 4).

Table 2-5: Additional Configuration Interface Signal Pinout

Signal	Direction	Description
configuration_vector_chx[5:0] <sup>(1)</sup>	Input	<p>Bit[0]: Unidirectional Enable When set to 1, Enable Transmit irrespective of the state of RX. When set to 0, Normal operation</p> <p>Bit[1]: Reserved</p> <p>Bit[2]: Power Down When set to 1, the device-specific transceiver is placed in a low-power state. A reset must be applied to clear. MDIO must be present to apply reset. This bit is valid only on <code>configuration_vector_ch0</code> and is reserved in other instances of <code>configuration_vector</code>.</p> <p>Bit[3] Isolate When set to 1, the GMII should be electrically isolated. When set to 0, normal operation is enabled</p> <p>Bit[4] Auto-Negotiation Enable This signal is valid only if the Auto-Negotiation (AN) module is enabled through the Vivado IP catalog. When set to 1, the signal enables the AN feature. When set to 0, AN is disabled.</p> <p>Bit[5] <code>gt_channel_valid</code> This signal is valid only for 7 series devices. This enables the contribution of <code>status_vector_chx[1]</code> signal towards the generation of data valid for <code>GT_RX_FSM</code>. This signal should be enabled based on the channel validity.</p>
configuration_vector_valid_chx <sup>(1)</sup>	Input	<p>This signal is valid only when the MDIO interface is present. The rising edge of this signal is the enable signal to overwrite the Register 0 contents that were written from the MDIO interface. For triggering a fresh update of Register 0 through <code>configuration_vector_chx</code>, this signal should be deasserted and then reasserted.</p>

Table 2-5: Additional Configuration Interface Signal Pinout (Cont'd)

Signal	Direction	Description
an_adv_config_vector_chx[15:0] <sup>(1)</sup>	Input	<p>QSGMII operating in MAC Mode, the AN_ADV register is hard wired internally to "0x0001" and this bus has no effect. For QSGMII operating in PHY mode, the AN_ADV register is programmed by this bus as specified for the following bits.</p> <p>Bit[0]: Always 1</p> <p>Bits [9:1]: Reserved</p> <p>Bits [11:10]: Speed</p> <p>1 1 Reserved</p> <p>1 0 1000 Mb/s</p> <p>0 1 100 Mb/s</p> <p>0 0 10 Mb/s</p> <p>Bits [12]: Duplex Mode</p> <p>1 Full Duplex</p> <p>0 Half Duplex</p> <p>Bit[13]: Reserved</p> <p>Bit [14]: Acknowledge</p> <p>Bit [15]: PHY Link Status</p> <p>1 Link Up</p> <p>0 Link Down</p>
an_adv_config_valid_chx <sup>(1)</sup>	Input	<p>This signal is valid only when the MDIO interface is present. The rising edge of this signal is the enable signal to overwrite the Register 4 contents that were written from the MDIO interface. For triggering a fresh update of Register 4 through an_adv_config_vector_chx, this signal should be deasserted and then reasserted.</p>
an_restart_config_chx <sup>(1)</sup>	Input	<p>This signal is valid only when AN is present. The rising edge of this signal is the enable signal to overwrite Bit 9 of Register 0. For triggering a fresh AN Start, this signal should be deasserted and then reasserted.</p>

Table 2-5: Additional Configuration Interface Signal Pinout (Cont'd)

Signal	Direction	Description
status_vector_chx[15:0] <sup>(1)</sup>	Output	<ul style="list-style-type: none"> <li>• Bit[0]: Link Status This signal indicates the status of the link. When High, the link is valid; synchronization of the link has been obtained and Auto-Negotiation (if present and enabled) has successfully completed. When Low, a valid link has not been established. Either link synchronization has failed or Auto-Negotiation (if present and enabled) has failed to complete.  When auto-negotiation is enabled, this signal is identical to Status register Bit 1.2: Link Status.  When auto-negotiation is disabled, this signal is identical to status_vector_chx Bit[1].</li> </ul>
		<ul style="list-style-type: none"> <li>• Bit[1]: Link Synchronization This signal indicates the state of the synchronization state machine (<i>IEEE 802.3</i> figure 36-9) which is based on the reception of valid 8B/10B code groups. This signal is similar to Bit[0] (Link Status), but is not qualified with Auto-Negotiation.  When High, link synchronization has been obtained and in the synchronization state machine, sync_status=OK.  When Low, synchronization has failed.</li> </ul>
		<ul style="list-style-type: none"> <li>• Bit[2]: RUDI(/C/) The core is receiving /C/ ordered sets (Auto-Negotiation Configuration sequences).</li> </ul>
		<ul style="list-style-type: none"> <li>• Bit[3]: RUDI(/I/) The core is receiving /I/ ordered sets (Idles).</li> </ul>
		<ul style="list-style-type: none"> <li>• Bit[4]: RUDI(INVALID) The core has received invalid data while receiving /C/ or /I/ ordered set.</li> </ul>
		<ul style="list-style-type: none"> <li>• Bit[5]: RXDISPERR The core has received a running disparity error during the 8B/10B decoding function.</li> </ul>

Table 2-5: Additional Configuration Interface Signal Pinout (Cont'd)

Signal	Direction	Description															
status_vector_chx[15:0] <sup>(1)</sup> (continued)	Output	<ul style="list-style-type: none"> <li>• Bit[6]: RXNOTINTABLE The core has received a code group that is not recognized from the 8B/10B coding tables.</li> </ul>															
		<ul style="list-style-type: none"> <li>• Bit[7]: PHY Link Status This bit represents the link status of the external PHY device attached to the other end of the QSGMII link (High indicates that the PHY has obtained a link with its link partner; Low indicates that it has not linked with its link partner.)</li> </ul>															
		<ul style="list-style-type: none"> <li>• Bit[9:8]: Remote Fault Encoding This signal indicates the remote fault encoding (<i>IEEE 802.3</i> table 37-3). This signal is validated by bit 13 of the <code>status_vector_chx</code> and is only valid when Auto-Negotiation is enabled.  This signal has no significance when the core is in PHY mode and indicates "00."</li> </ul>															
		<ul style="list-style-type: none"> <li>• Bit [11:10]: SPEED This signal indicates that the speed is negotiated and is only valid when Auto-Negotiation is enabled. The signal encoding follows:   <table border="0"> <tr> <td>Bit[11]</td> <td>Bit[10]</td> <td></td> </tr> <tr> <td>1</td> <td>1</td> <td>Reserved</td> </tr> <tr> <td>1</td> <td>0</td> <td>1000 Mb/s</td> </tr> <tr> <td>0</td> <td>1</td> <td>100 Mb/s</td> </tr> <tr> <td>0</td> <td>0</td> <td>10 Mb/s</td> </tr> </table> </li> </ul>	Bit[11]	Bit[10]		1	1	Reserved	1	0	1000 Mb/s	0	1	100 Mb/s	0	0	10 Mb/s
		Bit[11]	Bit[10]														
		1	1	Reserved													
1	0	1000 Mb/s															
0	1	100 Mb/s															
0	0	10 Mb/s															
<ul style="list-style-type: none"> <li>• Bit[12]: Duplex Mode This bit indicates the Duplex mode negotiated with the link partner.  1 = Full Duplex 0 = Half Duplex</li> </ul>																	
<ul style="list-style-type: none"> <li>• Bit[13] Remote Fault When this bit is logic 1, it indicates that a remote fault is detected and the type of remote fault is indicated by <code>status_vector_chx</code> bits[9:8].  <b>Note:</b> This bit is only deasserted when an MDIO read is made to status register (register 1). This signal has no significance in QSGMII PHY mode.</li> </ul>																	

Table 2-5: Additional Configuration Interface Signal Pinout (Cont'd)

Signal	Direction	Description
status_vector_chx[15:0] <sup>(1)</sup> (continued)	Output	Bits[15:14]: Pause These bits reflect the bits [8:7] of Register 5 (Link Partner Base AN register).  Bit[15] Bit[14] 0 0 No Pause 0 1 Symmetric Pause 1 0 Asymmetric Pause towards Link partner 1 1 Both Symmetric Pause and Asymmetric Pause towards link partner

**Notes:**

1. Signals are synchronous to the core internal 125 MHz reference clock `userclk2` when used with a device-specific transceiver.

### QSGMII Core Physical Side Interface

Table 2-6 describes the interface to the device-specific transceiver. The core is connected to the chosen transceiver in the appropriate HDL example design delivered with the core.

Table 2-6: Transceiver Interface Pinout

Signal	Direction	Description
mgt_rx_reset <sup>(1)</sup>	Output	Reset signal issued by the core to the device-specific transceiver receiver path. Connects to the <code>gtrxreset</code> signal of the device-specific transceiver. This reset is a combination of hard reset, soft reset and reset due to <code>rxbuffer</code> errors.
mgt_tx_reset <sup>(2)</sup>	Output	Reset signal issued by the core to the device-specific transceiver transmitter path. Connects to the <code>gtxreset</code> signal of the device-specific transceiver. This reset is a combination of hard reset, soft reset and reset due to <code>txbuffer</code> errors.
userclk	Input	Also connected to <code>txuserclk</code> of the device-specific transceiver. Clock domain is not applicable.
userclk2	Input	Also connected to <code>txuserclk2</code> of the device-specific transceiver. Clock domain is not applicable.
rxrecclk	Input	Also connected to <code>rxuserclk2</code> of the device-specific transceiver. Clock domain is not applicable.
dcm_locked	Input	A Digital Clock Manager (DCM) can be used to derive <code>userclk</code> and <code>userclk2</code> . This is implemented in the HDL design example delivered with the core. The core uses this input to hold the device-specific transceiver in reset until the DCM obtains lock. Clock domain is not applicable.
reset_done	Input	Indicates that both transceiver transmit and receive paths have completed reset cycle.
rxchariscomma[3:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.
rxcharisk[3:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.
rxdata[31:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.



Table 2-6: Transceiver Interface Pinout (Cont'd)

Signal	Direction	Description
rxdisperr[3:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.
rxnotintable[3:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.
rxrundisp[3:0] <sup>(1)</sup>	Input	Connects to device-specific transceiver signal of the same name.
txbuferr <sup>(2)</sup>	Input	Connects to device-specific transceiver signal of the same name.
powerdown <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.
txchardisp[3:0] <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.
txcharispval[3:0] <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.
txcharisk[3:0] <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.
txdata[31:0] <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.
enablealign <sup>(2)</sup>	Output	Connects to device-specific transceiver signal of the same name.

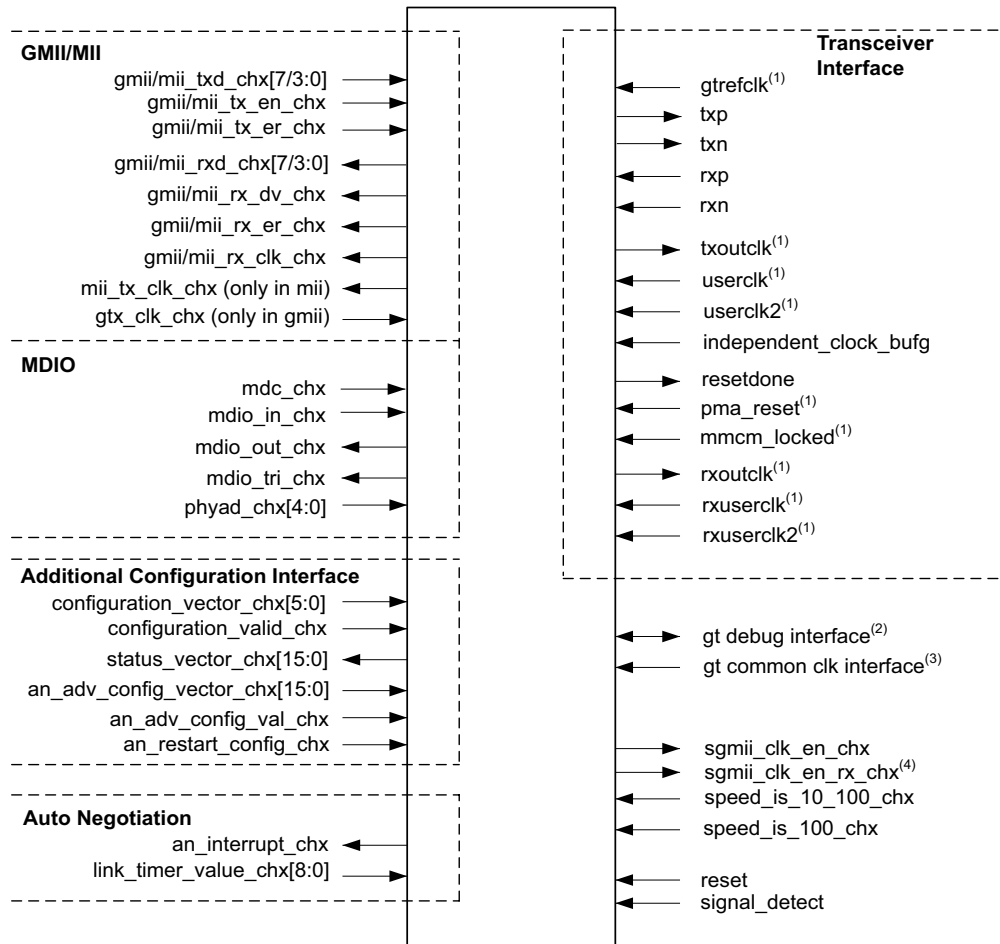
**Notes:**

1. When the core is used with a device-specific transceiver, `rxrecclk` is used as the 125 MHz reference clock for driving these signals.
2. When the core is used with a device-specific transceiver, `userclk2` is used as the 125 MHz reference clock for driving these signals.

## Block Hierarchy Level Ports

All the ports described here indicate the pins at the block level. The block level design instantiates the core and transceiver. The block level design is expected to be pulled from the IP catalog into the IP Canvas.

Figure 2-5 shows the pinout for the QSGMII block with the optional MDIO Management and optional Auto-Negotiation. The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."



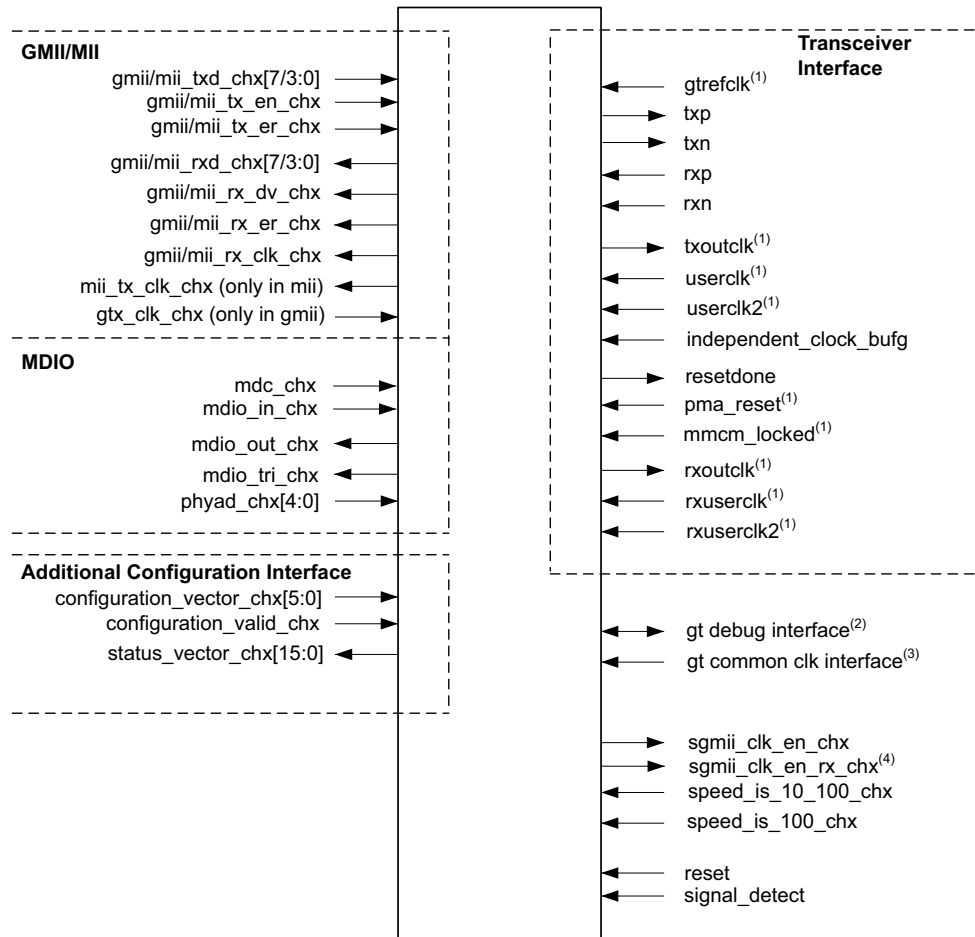
**Notes:**

1. These ports are available when **Include Shared Logic in Example Design** is selected (see Table 2-13). For ports available for **Include Shared Logic in Core**, see Table 2-14.
2. See Table 2-15 (Transceiver Control and Status Ports).
3. For **Include Shared Logic in Example Design** option, see GT Common Clock Interface section in Table 2-13. For **Include Shared Logic in Core**, see Table 2-14.
4. These ports are available when the RX path is on rsuserclk2.

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Figure 2-5: Component Pinout of QSGMII Block with Optional MDIO and Auto-Negotiation

Figure 2-6 shows the pinout for the QSGMII block with only optional MDIO Management. The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."



**Notes:**

1. These ports are available when **Include Shared Logic in Example Design** is selected (see Table 2-13). For ports available for **Include Shared Logic in Core**, see Table 2-14.
2. See Table 2-15 (Transceiver Control and Status Ports).
3. For **Include Shared Logic in Example Design** option, see GT Common Clock Interface section in Table 2-13. For **Include Shared Logic in Core**, see Table 2-14.
4. These ports are available when the RX path is on rsuserclk2.

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Figure 2-6: Component Pinout of QSGMII Block with Only Optional MDIO Management

Figure 2-7 shows the pinout for the QSGMII block with only optional Auto-Negotiation. The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."

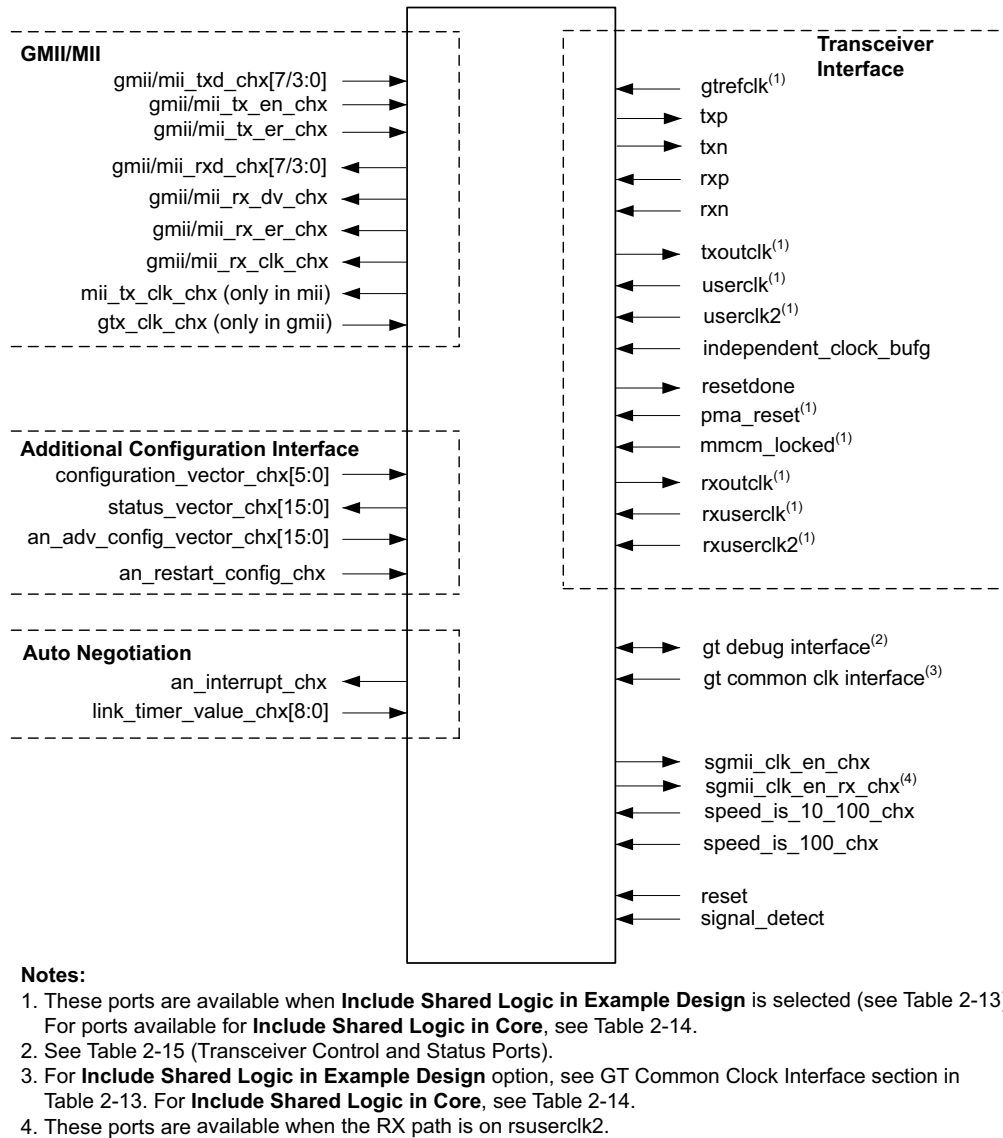
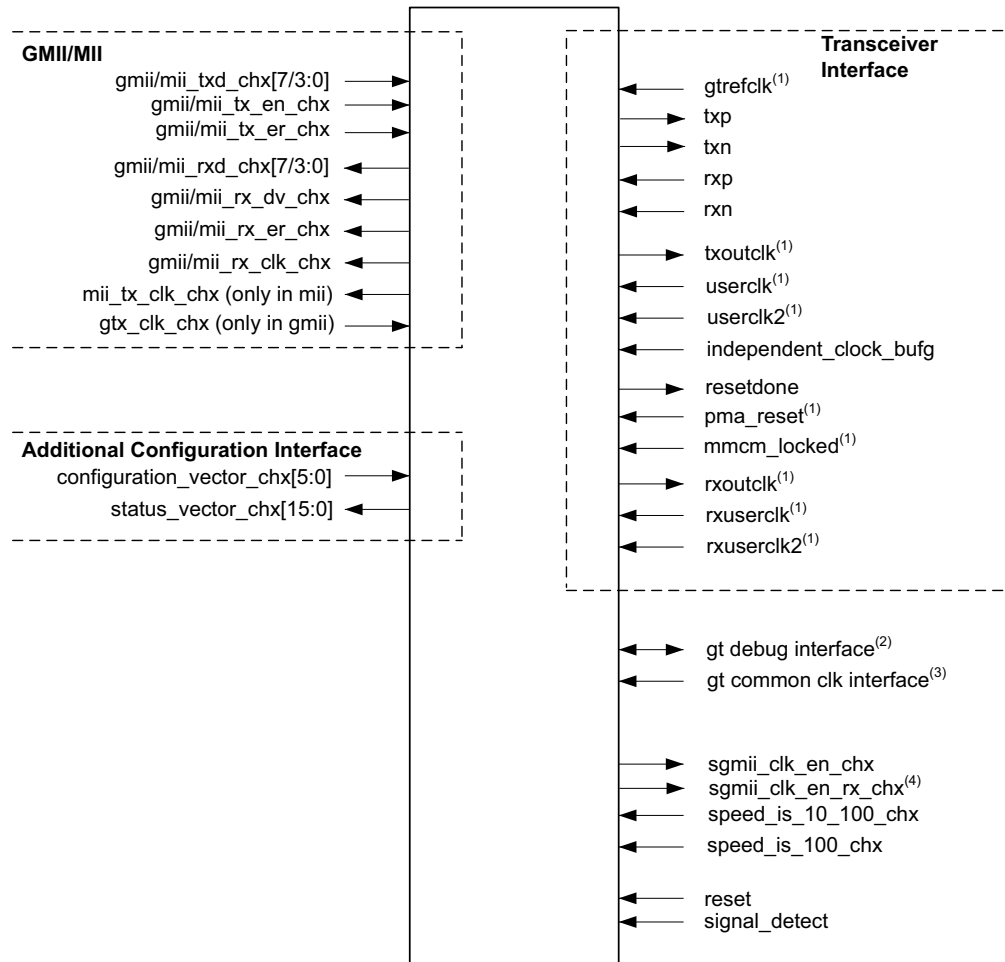


Figure 2-7: Component Pinout of QSGMII Block with Only Optional Auto-Negotiation

Figure 2-8 shows the pinout for the QSGMII block without optional MDIO or Auto-Negotiation. The port name for multiple instances of an interface is generalized as "CHx." "CHx" takes the value "CH0," "CH1," "CH2," and "CH3."



**Notes:**

1. These ports are available when **Include Shared Logic in Example Design** is selected (see Table 2-13). For ports available for **Include Shared Logic in Core**, see Table 2-14.
2. See Table 2-15 (Transceiver Control and Status Ports).
3. For **Include Shared Logic in Example Design** option, see GT Common Clock Interface section in Table 2-13. For **Include Shared Logic in Core**, see Table 2-14.
4. These ports are available when the RX path is on rsuserclk2.

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Figure 2-8: Component Pinout of QSGMII Block without Optional MDIO or Auto-Negotiation

### QSGMII Block Client Side Interface

This interface contains four groups of interfaces, with each group containing a set of the GMII/MII interface, the optional management interface if supported and configuration vectors. The interfaces end in "chx," taking the values ch0 to ch3, indicating the port connection to the respective GMII interface.

## GMII Pinout

This interface is enabled in the MAC mode or GMII configuration of PHY mode. In the MAC mode this interface is expected to be connected to the GMII interface of Tri-Mode Ethernet MAC core (TEMAC). In the GMII configuration of PHY mode, this interface is brought out onto the pads.

Table 2-7: GMII Interface Signals Pinout

Signal	Direction	Description
gmii_txd_chx[7:0] <sup>(1)</sup>	Input	GMII Transmit data
gmii_txd_en_chx <sup>(1)</sup>	Input	GMII Transmit data enable
gmii_tx_er_chx <sup>(1)</sup>	Input	GMII Transmit error
gmii_rxd_chx[7:0] <sup>(2)</sup>	Output	GMII Receive data
gmii_rxd_dv_chx <sup>(2)</sup>	Output	GMII Receive data valid
gmii_rx_er_chx <sup>(2)</sup>	Output	GMII Receive error
gtx_clk_chx	Input	GMII TX clock. This is valid only in GMII configuration in PHY mode
gmii_rx_clk_chx	Output	GMII RX clock. This is valid only in GMII configuration in PHY mode
sgmii_clk_en_chx	Output	Clock enables. This valid only in MAC mode.
sgmii_clk_en_rx_chx	Output	Clock enables. This valid only in MAC mode and when RX path is on rxuserclk2.

### Notes:

1. In MAC mode these signals are synchronous to 125 MHz reference clock of the core, that is, `userclk2`. In GMII configuration of PHY mode these signals are synchronous to `gtx_clk_chx` and these signals are synchronized to `userclk2` domain using Transmit Elastic Buffer present in the block
2. These signals are synchronous to 125 MHz reference clock of the core. This is `userclk2`.

Table 2-8: MII Interface Signals Pinout

Signal	Direction	Description
mii_txd_chx[7:0] <sup>(1)</sup>	Input	MII Transmit data
mii_tx_en_chx <sup>(1)</sup>	Input	MII Transmit data enable
mii_tx_er_chx <sup>(1)</sup>	Input	MII Transmit error
mii_rxd_chx[7:0] <sup>(2)</sup>	Output	MII Receive data
mii_rx_dv_chx <sup>(2)</sup>	Output	MII Receive data valid
mii_rx_er_chx <sup>(2)</sup>	Output	MII Receive data error
mii_tx_clk_chx	Output	MII TX clock. This is valid only in MII configuration in MII mode. The clock can be 2.5/25 MHz based on 10/100 Mb/s mode of operation

**Table 2-8: MII Interface Signals Pinout (Cont'd)**

Signal	Direction	Description
mii_rx_clk_chx	Output	MII RX clock. This is valid only in MII configuration in MII mode. The clock can be 2.5/25 MHz based on 10/100 Mb/s mode of operation

**Notes:**

1. These signals should be driven on mii\_tx\_clk\_chx.
2. These signals are synchronous to mii\_rx\_clk\_chx.

**Common Signals**

See [Table 2-2](#) of Common Signals section for these signals.

**MDIO Management Interface Pinout (Optional)**

See [Table 2-3](#) of MDIO Management Interface Pinout section for these signals.

**Auto-Negotiation Interface Pinout (Optional)**

See [Table 2-4](#) of Auto-Negotiation Interface Pinout section for these signals.

**Additional Configuration Interface**

See [Table 2-5](#) of Additional Configuration Interface Pinout section for these signals.

**QSGMII Block Physical Side Interface**

[Table 2-9](#) describes the interface to the device-specific transceiver for the case where shared logic is included in the example design.

**Table 2-9: QSGMII Block Physical Side Interface with Shared Logic in the Example Design**

Signal	Direction	Description
gtrefclk	Input	125 MHz reference clock from IBUFDS to the transceiver
txp	Output	Transmit differential
txn	Output	Transmit differential
rxp	Input	Receive differential
rxn	Input	Receive differential
txoutclk	Output	txoutclk from transceiver
userclk	Input	Also connected to txusrclk of the device-specific transceiver. Clock domain is not applicable
userclk2	Input	Also connected to txusrclk2 of the device-specific transceiver. Clock domain is not applicable.
rxoutclk	Output	rxoutclk from transceiver.

Table 2-9: QSGMII Block Physical Side Interface with Shared Logic in the Example Design

Signal	Direction	Description
rxuserclk	Input	Also connected to <code>rxusrclk</code> of the device-specific transceiver. Clock domain is not applicable.
rxuserclk2	Input	Also connected to <code>rxusrclk2</code> of the device-specific transceiver. Clock domain is not applicable.
independent_clock_bufg	Input	Stable clock used as stable clock in transceiver and also as control clock for IDELAYCTRL. This clock is 200 MHz for 7 series devices and 300 MHz for UltraScale+ families and UltraScale devices.
resetdone	Output	Indication that reset sequence of the transceiver is complete.
pma_reset	Input	Hard reset synchronized to <code>independent_clock_bufg</code> .
mmcm_locked	Input	Indication from the MMCM that the outputs are stable.
independent_clock_bufgdiv4	Input	Independent clock divided by 4. This clock is only present for UltraScale+ families and UltraScale devices when <b>Transceiver Control and Status Ports</b> are disabled.
<b>GT Common Clock Interface</b>		
gt0_pll0outclk_in	Input	Valid only for Artix-7 families. Indicates out clock from PLL0 of GT Common.
gt0_pll0outrefclk_in	Input	Valid only for Artix-7 families. Indicates reference out clock from PLL0 of GT Common.
gt0_pll1outclk_in	Input	Valid only for Artix-7 families. Indicates out clock from PLL1 of GT Common.
gt0_pll1outrefclk_in	Input	Valid only for Artix-7 families. Indicates reference out clock from PLL1 of GT Common.
gt0_pll0lock_in	Input	Valid only for Artix-7 families. Indicates out PLL0 of GT Common has locked.
gt0_pll0refclklost_in	Input	Valid only for Artix-7 families. Indicates out reference clock for PLL0 of GT Common is lost.



**Table 2-9: QSGMII Block Physical Side Interface with Shared Logic in the Example Design**

Signal	Direction	Description
gt0_pll0reset_out	Output	Valid only for Artix-7 families. Reset for PLL of GT Common from reset fsm in GT Wizard.
gt0_qplloutclk_in	Input	Valid only for non Artix-7 families. Indicates out clock from PLL of GT Common.
gt0_qplloutrefclk_in	Input	Valid only for non Artix-7 families. Indicates reference out clock from PLL of GT Common.

Table 2-10 describes the interface to the device-specific transceiver when shared logic is in the core.

**Table 2-10: QSGMII Block Physical Side Interface with Shared Logic in the Core**

Signal	Direction	Description
gtrefclk_p	Input	125 MHz differential reference clock to IBUFDS
gtrefclk_n	Input	125 MHz differential reference clock to IBUFDS
gtrefclk_out	Output	125 MHz reference clock from IBUFDS
txp	Output	Transmit differential
txn	Output	Transmit differential
rxp	Input	Receive differential
rxn	Input	Receive differential
userclk_out	Output	Also connected to txusrclk of the device-specific transceiver. Clock domain is not applicable.
userclk2_out	Output	Also connected to txusrclk2 of the device-specific transceiver. Clock domain is not applicable.
rxuserclk_out	Output	Also connected to rxusrclk of the device-specific transceiver. Clock domain is not applicable.
rxuserclk2_out	Output	Also connected to rxusrclk2 of the device-specific transceiver. Clock domain is not applicable.
independent_clock_bufg	Input	Stable clock used as stable clock in transceiver and also as control clock for IDELAYCTRL. This clock is 200 MHz for 7 series devices and 300 MHz for UltraScale+ families and UltraScale devices.

Table 2-10: QSGMII Block Physical Side Interface with Shared Logic in the Core (Cont'd)

Signal	Direction	Description
resetdone	Output	Indication that reset sequence of the transceiver is complete.
pma_reset_out	Output	Hard reset synchronized to <code>independent_clock_bufg</code> .
mmcm_locked_out	Output	Indication from the MMCM that the outputs are stable.
independent_clock_bufgdiv4_out	Output	Independent clock divided by 4. This clock is only present for UltraScale+ families and UltraScale devices when <b>Transceiver Control and Status Ports</b> are disabled.
<b>GT Common Clock Interface</b>		
gt0_pll0outclk_out	Output	Valid only for Artix-7 families. Indicates out clock from PLL0 of GT Common.
gt0_pll0outrefclk_out	Output	Valid only for Artix-7 families. Indicates reference out clock from PLL0 of GT Common.
gt0_pll1outclk_out	Output	Valid only for Artix-7 families. Indicates out clock from PLL1 of GT Common.
gt0_pll1outrefclk_out	Output	Valid only for Artix-7 families. Indicates reference out clock from PLL1 of GT Common.
gt0_pll0lock_out	Output	Valid only for Artix-7 families. Indicates out PLL0 of GT Common has locked.
gt0_pll0refclklost_out	Output	Valid only for Artix-7 families. Indicates out reference clock for PLL0 of GT Common is lost.
gt0_qplloutclk_out	Output	Valid only for non Artix-7 families. Indicates out clock from PLL of GT Common.
gt0_qplloutrefclk_out	Output	Valid only for non Artix-7 families. Indicates reference out clock from PLL of GT Common.

## Transceiver Control and Status Ports

This section describes optional ports that, if enabled, allow the monitoring and control of certain important transceiver ports. When not selected, these ports are tied to their default values.



**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 2-11](#) might result in unpredictable behavior of the IP core.

**Note:** The Dynamic Reconfiguration Port is only available if this option is selected. Also for UltraScale+ families and UltraScale devices, the prefix of ports in [Table 2-11](#) are changed from "gt0" to "gt" and the suffix "\_in" and "\_out" are dropped.

Table 2-11: Transceiver Control and Status Ports

Signal	Direction	Clock Domain	Description
gt0_drp_addr_in[8:0]	Input	gt0_drpclk_in	DRP address bus drp_en IN DRP enable signal. 0: No read or write operation performed. 1: enables a read or write operation.
gt0_drpi_in[15:0]	Input	gt0_drpclk_in	Data bus for writing configuration data to the transceiver.
gt0_drpo_out[15:0]	Output	gt0_drpclk_in	Data bus for reading configuration data from the transceiver.
gt0_drprdy_out	Output	gt0_drpclk_in	Indicates operation is complete for write operations and data is valid for read operations.
gt0_drp_busy_out	Output	gt0_drpclk_in	Output valid only for Artix-7 family. Indicates that DRP interface is busy. This bit should be checked before any transaction is posted on DRP interface.
gt0_drpwe_in	Input	gt0_drpclk_in	DRP write enable. 0: Read operation when DRPEN is 1. 1: Write operation when DRPEN is 1.
gt0_drpclk_in	Input	N/A	DRP Clock
gt0_rxchariscomma_out[3:0]	Output	rxuserclk2	GT Status
gt0_rxcharisk_out[3:0]	Output		
gt0_rxbyteisaligned_out	Output		
gt0_rxbyterealign_out	Output		
gt0_rxcommadet_out	Output		

Table 2-11: Transceiver Control and Status Ports (Cont'd)

Signal	Direction	Clock Domain	Description
gt0_txdiffctrl_in[3:0]	Input	Async	GT TX Driver
gt0_txpostcursor_in[4:0]	Input	Async	
gt0_txprecursor_in[4:0]	Input	Async	
gt0_txpolarity_in	Input	userclk2	GT Polarity
gt0_rxpolarity_in	Input	rxuserclk2	
gt0_txprbssel_in[2:0]	Input	userclk2	GT PRBS
gt0_txprbsforceerr_in	Input	userclk2	
gt0_rxprbscntreset_in	Input	rxuserclk2	
gt0_rxprbserr_out	Output	rxuserclk2	
gt0_rxprbssel_in[2:0]	Input	rxuserclk2	
gt0_loopback_in[2:0]	Input	Async	GT Loopback
gt0_txresetdone_out	Output	userclk2	GT Status
gt0_rxresetdone_out	Output	rxuserclk2	
gt0_rxdisperr_out[3:0]	Output	rxuserclk2	
gt0_rxnotintable_out[3:0]	Output	rxuserclk2	
gt0_eyescanreset_in[3:0]	Input	Async	GT Eye Scan
gt0_eyescanataerror_out	Output	Async	
gt0_eyescantrigger_in	Input	rxuserclk2	
gt0_rxrate_in[2:0]	Input	rxuserclk2	
gt0_rxcdrhold_in	Input	Async	GT CDR
gt0_rxcdrlock_out	Output		
gt0_rxratedone_out	Output	rxuserclk2	GT Fabric Clock Output Control
gt0_rxlpmhfhold_in	Input	Async	GT GTP Low Power Mode (LPM)
gt0_rxlplmfhold_in	Input		
gt0_rxlpmhfvrden_in	Input		
gt0_rxlpmreset_in	Input		
gt0_rxlpmen_in	Input	Async	GT GTX/GTH RX Decision Feedback Equalizer (DFE)
gt0_rxdfelprmreset_in	Input		
gt0_rxdfeagcovrden_in	Input	rxuserclk2	
gt0_rxmonitorout_out[6:0]	Output	Async	
gt0_rxmonitorsel_in[1:0]	Input		
gt0_dmonitorout_out[16:0]	Output		
gt0_gttxreset_in	Input	Async	TX Reset (gt0_gttxreset_in present in only non-UltraScale devices).
gt0_txpcreset_in	Input		
gt0_txpmarereset_in	Input		

Table 2-11: Transceiver Control and Status Ports (Cont'd)

Signal	Direction	Clock Domain	Description
gt0_gtrxreset_in	Input	Async	RX Reset (gt0_gtrxreset_in present in only non-UltraScale devices. gt0_rxpmaresetdone_out is tied to 1 for devices supporting GTX transceivers).
gt0_rxpcsreset_in	Input		
gt0_rxpmareset_in	Input		
gt0_rxpmaresetdone_out	Output		
gt0_cpplllock_out	Output	Async	Channel PLL locked. Present only in non GTP transceiver devices.
gt0_txbufstatus_out[1:0]	Output	userclk2	Transmitter buffer status.
gt0_txinhibit_in	Input	userclk2	Blocks transmission.
gt_pcsrsvdin[15:0]	Input	Async	DRP Reset. Available only for UltraScale+ families and UltraScale devices.
gt_powergood_out	Output	Async	Indicates power is good. Available only for UltraScale and UltraScale+ devices.

## Register Space

### MDIO Management System

This section gives the description of one instance MDIO\_CH0 of the four instances of the MDIO Management System. The other instances follow the same actions.

When the optional MDIO Management Interface is selected, the configuration and status of the SGMII module instance is achieved by the Management registers accessed through the serial Management Data Input/Output Interface (MDIO).

#### **MDIO Bus System**

The MDIO interface for 1 Gb/s operation (and slower speeds) is defined in *IEEE 802.3-2008 Specification* [Ref 2], clause 22. [Figure 2-9](#) illustrates an example MDIO bus system. This two-wire interface consists of a clock (MDC) and a shared serial data line (MDIO). The maximum permitted frequency of MDC is set at 2.5 MHz. An Ethernet MAC is shown as the MDIO bus master (the Station Management (STA) entity). Two PHY devices are shown

connected to the same bus, both of which are MDIO slaves (MDIO Managed Device (MMD) entities).

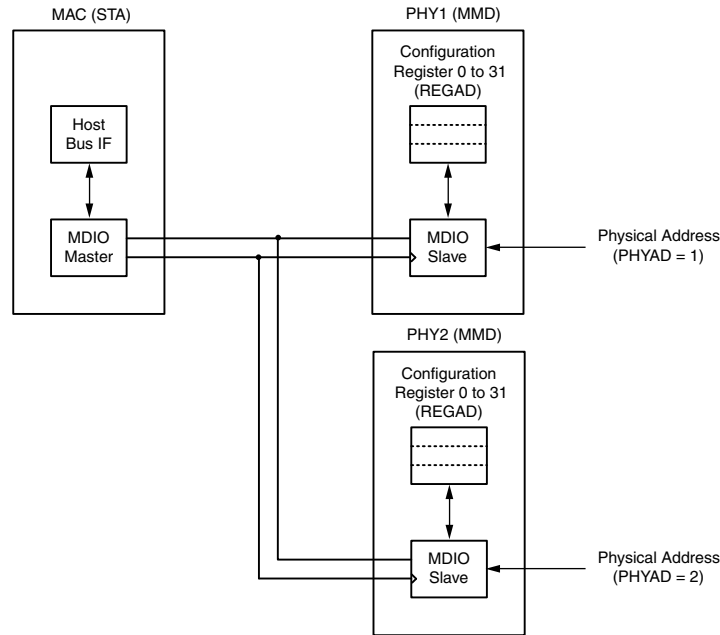


Figure 2-9: Typical MDIO Managed System

The MDIO bus system is a standardized interface for accessing the configuration and status registers of Ethernet PHY devices. In the example illustrated, the Management Host Bus I/F of the Ethernet MAC is able to access the configuration and status registers of two PHY devices through the MDIO bus.

### MDIO Transactions

All transactions, read or write, are initiated by the MDIO master. All MDIO slave devices, when addressed, must respond. MDIO transactions take the form of an MDIO frame, containing fields for transaction type, address and data. This MDIO frame is transferred across the MDIO wire synchronously to MDC. The abbreviations that are used in this section are explained in Table 2-12.

Table 2-12: Abbreviations and Terms

Abbreviation	Term
PRE	Preamble
ST	Start of Frame
OP	Operation Code
PHYAD	Physical Address

Table 2-12: Abbreviations and Terms (Cont'd)

Abbreviation	Term
REGAD	Register Address
TA	Turnaround

### Write Transaction

Figure 2-10 shows a write transaction across the MDIO, defined as OP = "01." The addressed PHY device (with physical address PHYAD) takes the 16-bit word in the Data field and writes it to the register at REGAD.

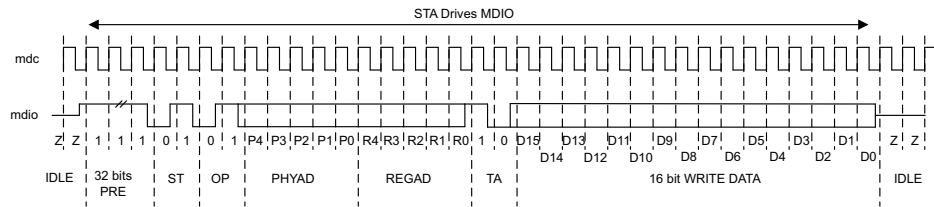


Figure 2-10: MDIO Write Transaction

### Read Transaction

Figure 2-11 shows a read transaction, defined as OP = "10." The addressed PHY device (with physical address PHYAD) takes control of the MDIO wire during the turn-around cycle and then returns the 16-bit word from the register at REGAD.

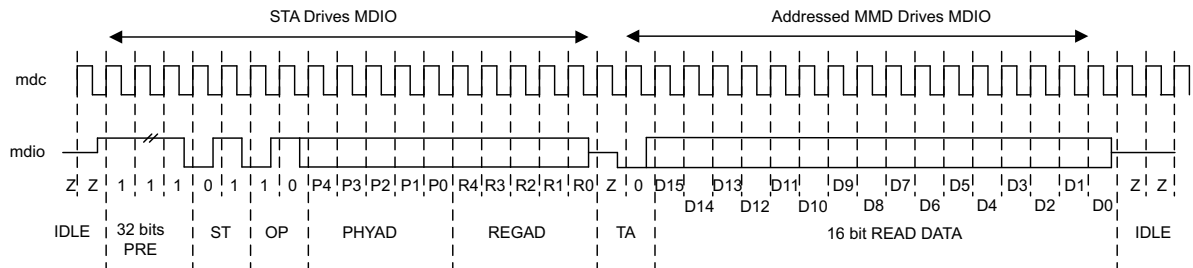


Figure 2-11: MDIO Read Transaction

### MDIO Addressing

MDIO Addresses consists of two stages: Physical Address (PHYAD) and Register Address (REGAD).

### Physical Address (PHYAD)

As shown in [Figure 2-9](#), two PHY devices are attached to the MDIO bus. Each of these has a different physical address. To address the intended PHY, its physical address should be known by the MDIO master (in this case an Ethernet MAC) and placed into the PHYAD field of the MDIO frame (see [MDIO Transactions](#)).

The PHYAD field for an MDIO frame is a 5-bit binary value capable of addressing 32 unique addresses. However, every MDIO slave must respond to physical address 0. This requirement dictates that the physical address for any particular PHY must not be set to 0 to avoid MDIO contention. Physical Addresses 1 through 31 can be used to connect up to 31 PHY devices onto a single MDIO bus.

### Register Address (REGAD)

Having targeted a particular PHY using PHYAD, the individual configuration or status register within that particular PHY must now be addressed. This is achieved by placing the individual register address into the REGAD field of the MDIO frame (see [MDIO Transactions](#)).

The REGAD field for an MDIO frame is a 5-bit binary value capable of addressing 32 unique addresses. The first 16 of these (registers 0 to 15) are defined by the *IEEE 802.3-2008 Specification* [\[Ref 2\]](#). The remaining 16 (registers 16 to 31) are reserved for PHY vendors own register definitions.

For details of the register map of PHY layer devices and a more extensive description of the operation of the MDIO Interface, see *IEEE 802.3-2008 Specification* [\[Ref 2\]](#).

### **Connecting the MDIO to an Internally Integrated STA**

The MDIO ports of the QSGMII core can be connected to the MDIO ports of an internally integrated Station Management (STA) entity, such as the MDIO port of multi-instances of the Tri-Mode Ethernet MAC core.

### **Connecting the MDIO to an External STA**

[Figure 2-12](#) shows the MDIO ports of the QSGMII core connected to the MDIO of an external STA entity. In this situation, `mdio_in_chx`, `mdio_out_chx`, and `mdio_tri_chx` must be connected to a 3-state buffer to create a bidirectional wire, `mdio_chx`.

This 3-state buffer can either be external to the FPGA or internally integrated by using an IOB IOBUF component with an appropriate SelectIO™ interface standard suitable for the external PHY.



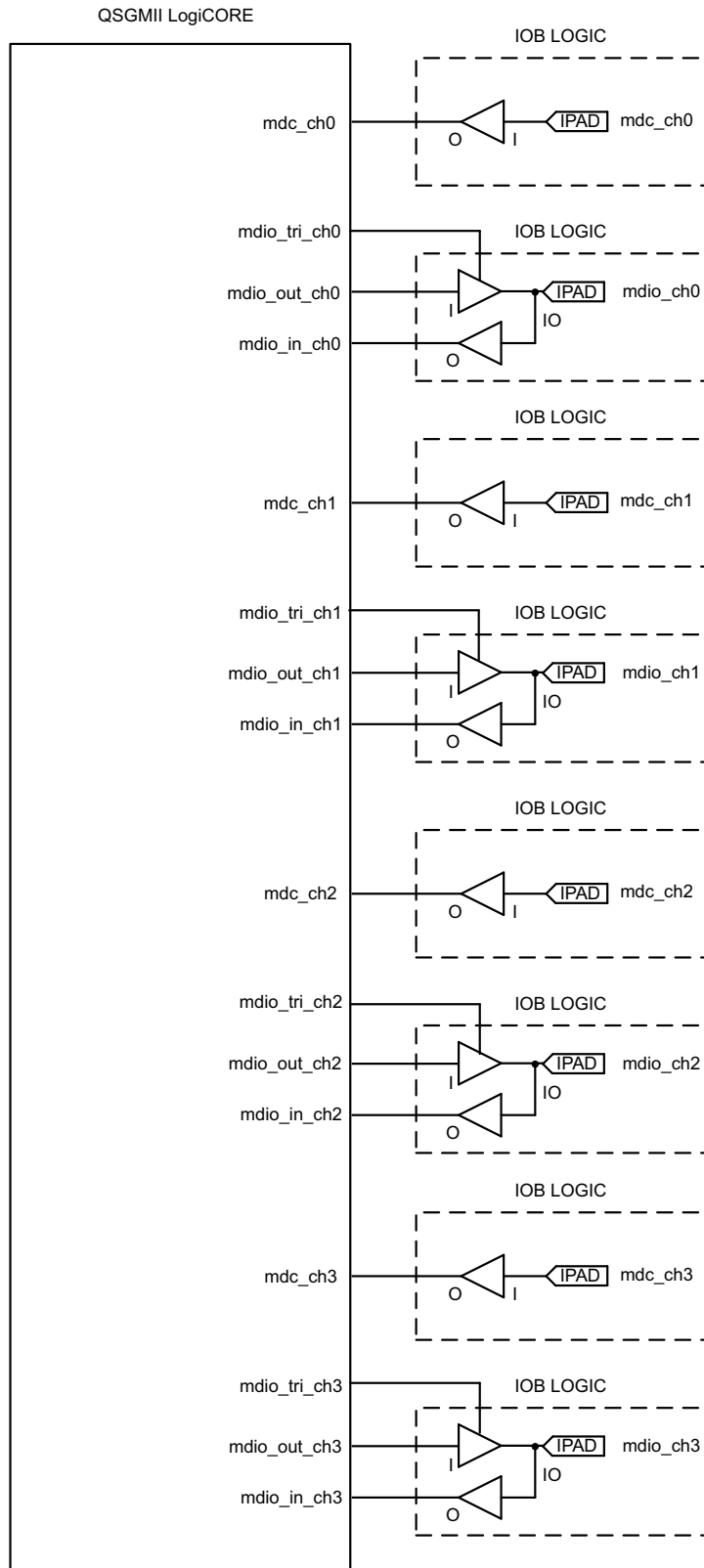


Figure 2-12: Creating an External MDIO Interface

## Management Registers

The contents of the Management registers can be accessed using the REGAD field of the MDIO frame. Contents vary depending on the Xilinx Vivado design tool options, and are defined in the following sections in this guide.

- [QSGMII Using Optional Auto-Negotiation](#)
- [QSGMII Without Optional Auto-Negotiation](#)

### ***QSGMII Using Optional Auto-Negotiation***

The registers provided are duplicated for each instance of the SGMII module in this core. The registers are adaptations of those defined in clauses 22 and 37 of the *IEEE 802.3-2008 Specification* [Ref 2]. In a QSGMII implementation, two different types of links exist. They are the QSGMII link between the MAC and PHY (QSGMII link) and the link across the Ethernet Medium itself (Medium).

Information regarding the state of both of these links is contained within the registers described in [Table 2-13](#) through [Table 2-26](#). Where applicable, the abbreviations QSGMII link and Medium are used in the register descriptions. Registers at undefined addresses are read-only and return 0s.

**Table 2-13: Management Registers for QSGMII with Auto-Negotiation**

Register Address	Register Name
0	SGMII Control Register
1	SGMII Status Register
2, 3	PHY Identifier
4	SGMII Auto-Negotiation Advertisement Register
5	SGMII Auto-Negotiation Link Partner Ability Base Register
6	SGMII Auto-Negotiation Expansion Register
7	SGMII Auto-Negotiation Next Page Transmit Register
8	SGMII Auto-Negotiation Next Page Receive Register
15	SGMII Extended Status Register
16	SGMII Vendor Specific: Auto-Negotiation Interrupt Control
18	SGMII Generic Control

**Register 0: SGMII Control Register**

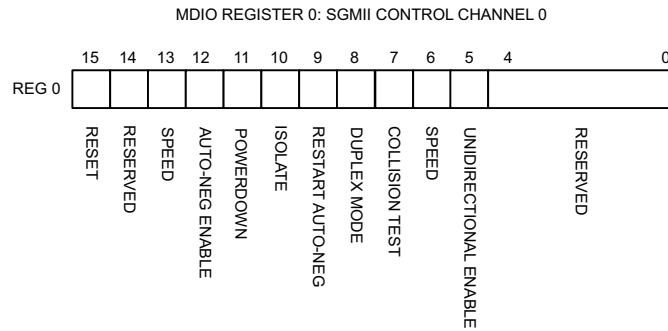


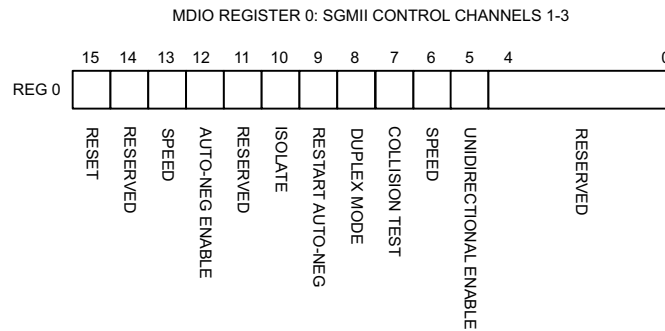
Figure 2-13: MDIO Register 0: SGMII Control Register Channel/Module 0

Table 2-14: SGMII Control Register Channel/Module 0 (Register 0)

Bits	Name	Description	Attributes	Default Value
0.15	Reset	1 = SGMII module 0 Reset 0 = Normal Operation	read/write self clearing	0
0.14	Reserved	Returns what is written	read/write	0
0.13	Speed Selection (LSB)	Always returns a '0' for this bit. Together with bit 0.6, speed selection of 1000 Mb/s is identified.	returns 0	0
0.12	Auto-Negotiation Enable	1 = Enable SGMII Auto-Negotiation Process 0 = Disable SGMII Auto-Negotiation Process	read/write	1
0.11	Power Down	1 = Power down 0 = Normal operation When set to 1, the device-specific transceiver is placed in a low-power state. This bit requires a reset (see bit 0.15) to clear.	read/ write	0
0.10	Isolate	1 = Electrically Isolate SGMII logic from GMII 0 = Normal operation	read/write	1
0.9	Restart Auto- Negotiation	1 = Restart Auto-Negotiation Process across SGMII link 0 = Normal Operation	read/write self clearing	0
0.8	Duplex Mode	Always returns a 1 for this bit to signal Full-Duplex Mode	returns 1	1

**Table 2-14: SGMII Control Register Channel/Module 0 (Register 0) (Cont'd)**

Bits	Name	Description	Attributes	Default Value
0.7	Collision Test	Always returns a 0 for this bit to disable Collision (COL) test	returns 0	0
0.6	Speed Selection (MSB)	Always returns a 1 for this bit. Together with bit 0.13, speed selection of 1000 Mb/s is identified.	returns 1	1
0.5	Unidirectional al Enable	Enable transmit regardless of whether a valid link has been established provided AN is disabled.	read/ write	0
0.4:0.0	Reserved	Always return 0s, writes ignored.	returns 0s	00000



**Figure 2-14: MDIO Register 0: SGMII Control Channels/Modules 1-3**

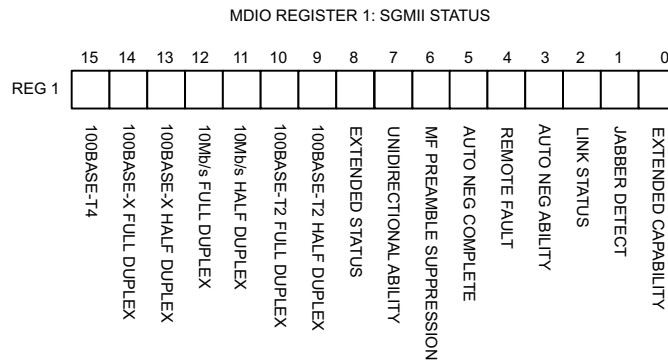
**Table 2-15: SGMII Control Register Channels/Modules 1-3 (Register 0)**

Bits	Name	Description	Attributes	Default Value
0.15	Reset	1 = SGMII module 1-3 Reset 0 = Normal Operation	read/write self clearing	0
0.14	Reserved	Returns what is written	read/write	0
0.13	Speed Selection (LSB)	Always returns a 0 for this bit. Together with bit 0.6, speed selection of 1000 Mb/s is identified.	returns 0	0
0.12	Auto-Negotiation Enable	1 = Enable SGMII Auto-Negotiation Process 0 = Disable SGMII Auto-Negotiation Process	read/write	1
0.11	Reserved	Returns what is written	read/ write	0

**Table 2-15: SGMII Control Register Channels/Modules 1-3 (Register 0)**

Bits	Name	Description	Attributes	Default Value
0.10	Isolate	1 = Electrically Isolate SGMII logic from GMII 0 = Normal operation	read/write	1
0.9	Restart Auto-Negotiation	1 = Restart Auto-Negotiation Process across SGMII link 0 = Normal Operation	read/write self clearing	0
0.8	Duplex Mode	Always returns a 1 for this bit to signal Full-Duplex Mode	returns 1	1
0.7	Collision Test	Always returns a 0 for this bit to disable COL test	returns 0	0
0.6	Speed Selection (MSB)	Always returns a 1 for this bit. Together with bit 0.13, speed selection of 1000 Mb/s is identified.	returns 1	1
0.5	Unidirectional Enable	Enable transmit regardless of whether a valid link has been established provided AN is disabled.	read/ write	0
0.4:0.0	Reserved	Always return 0s, writes ignored	returns 0s	00000

**Register 1: SGMII Status Register**



**Figure 2-15: MDIO Register 1: SGMII Status Register**

Table 2-16: SGMII Status Register (Register 1)

Bits	Name	Description	Attributes	Default Value
1.15	100BASE-T4	Always returns a 0 for this bit because 100BASE-T4 is not supported.	returns 0	0
1.14	100BASE-X Full Duplex	Always returns a 0 for this bit because 100BASE-X Full Duplex is not supported.	returns 0	0
1.13	100BASE-X Half Duplex	Always returns a 0 for this bit because 100BASE-X Half Duplex is not supported.	returns 0	0
1.12	10 Mb/s Full Duplex	Always returns a 0 for this bit because 10 Mb/s Full Duplex is not supported.	returns 0	0
1.11	10 Mb/s Half Duplex	Always returns a 0 for this bit because 10 Mb/s Half Duplex is not supported.	returns 0	0
1.10	100BASE-T2 Full Duplex	Always returns a 0 for this bit because 100BASE-T2 Full Duplex is not supported.	returns 0	0
1.9	100BASE-T2 Half Duplex	Always returns a 0 for this bit because 100BASE-T2 Half Duplex is not supported.	returns 0	0
1.8	Extended Status	Always returns a 1 for this bit to indicate the presence of the Extended register (Register 15).	returns 1	1
1.7	Unidirectional Ability	Always returns 1, writes ignored.	returns 1	1
1.6	MF Preamble Suppression	Always returns a 1 for this bit to indicate that Management Frame Preamble Suppression is supported.	returns 1	1
1.5	Auto- Negotiation Complete	1 = Auto-Negotiation process completed across SGMII link. 0 = Auto-Negotiation process not completed across SGMII link.	read only	0
1.4	Remote Fault	1 = A fault on the Medium has been detected. 0 = No fault of the Medium has been detected.	read only self clearing on read	0
1.3	Auto- Negotiation Ability	Always returns a 1 for this bit to indicate that the SGMII core is capable of Auto-Negotiation.	returns 1	1
1.2	SGMII Link Status	1 = SGMII Link is up 0 = SGMII Link is down Latches 0 if SGMII Link Status goes down. Clears to current SGMII Link Status on read. See the following <a href="#">Link Status</a> section for further details.	read only self clearing on read	0

Table 2-16: SGMII Status Register (Register 1) (Cont'd)

Bits	Name	Description	Attributes	Default Value
1.1	Jabber Detect	Always returns a 0 for this bit because Jabber Detect is not supported.	returns 0	0
1.0	Extended Capability	Always returns a 0 for this bit because no extended register set is supported.	returns 0	0

### Link Status

When High, the link is valid and has remained valid after this register was last read; synchronization of the link has been obtained and Auto-Negotiation (if enabled) has completed.

When Low, either:

- A valid link has not been established; link synchronization has failed or Auto-Negotiation (if enabled) has failed to complete.

OR

- Link synchronization was lost at some point after this register was previously read. However, the current link status might be good. Therefore read this register a second time to get confirmation of the current link status.

Regardless of whether Auto-Negotiation is enabled or disabled, there can be some delay in the deassertion of Link Status following the loss of synchronization of a previously successful link. This is because the Auto-Negotiation state machine that requires that synchronization is lost for an entire link timer duration before changing state. For more information, see the *802.3-2008 Specification* [Ref 2] (the `an_sync_status` variable).

**Registers 2 and 3 (PHY IDENTIFIER)**

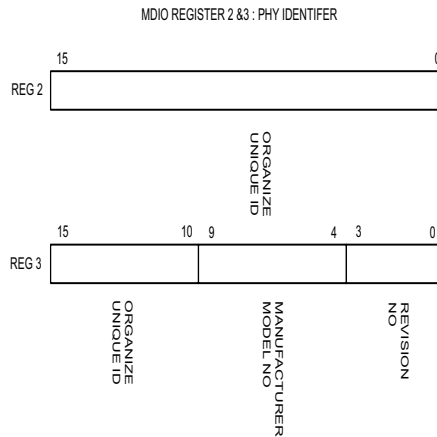


Figure 2-16: MDIO Registers 2 and 3: (PHY IDENTIFIER)

Table 2-17: PHY Identifier (Registers 2 and 3)

Bits	Name	Description	Attributes	Default Value
2.15:0	Organizationally Unique Identifier	Always return 0s	returns 0s	0000000000000000
3.15:10	Organizationally Unique Identifier	Always return 0s	returns 0s	000000
3.9:4	Manufacturer model number	Always return 0s	returns 0s	000000
3.3:0	Revision Number	Always return 0s	returns 0s	0000

**Register 4: SGMII Auto-Negotiation Advertisement**

MAC Mode Of Operation

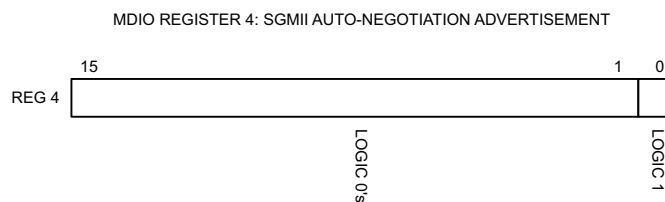


Figure 2-17: MDIO Register 4: SGMII Auto-Negotiation Advertisement

Table 2-18: SGMII Auto-Negotiation Advertisement (Register 4)

Bits	Name	Description	Attributes	Default Value
4.15:0	All bits	SGMII defined value sent from the MAC to the PHY.	read only	0100000000000001



PHY Mode Of Operation

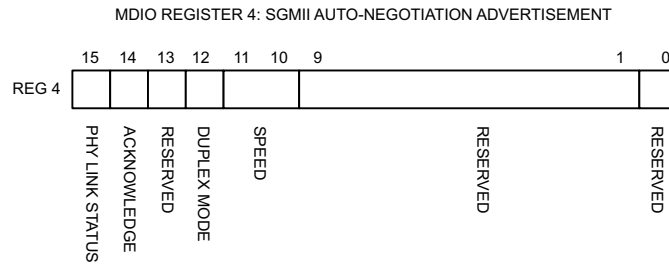
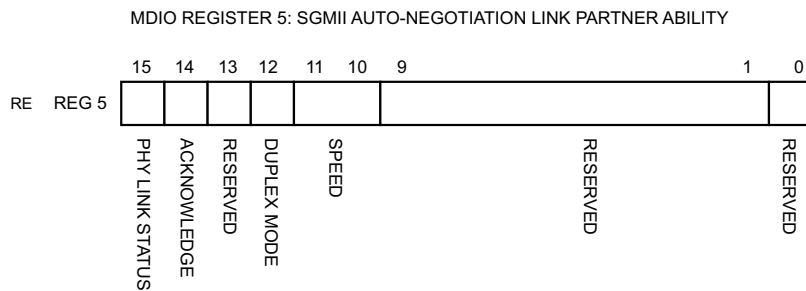


Figure 2-18: MDIO Register 4: SGMII Auto-Negotiation Advertisement

Table 2-19: SGMII Auto-Negotiation Advertisement in PHY Mode (Register 4)

Bits	Name	Description	Attributes	Default Value
4.15	PHY Link Status	This refers to the link status of the PHY with its link partner across the Medium. 1 = Link Up 0 = Link Down	read/write	0
4.14	Acknowledge	Used by Auto-Negotiation function to indicate reception of a link partner base or next page.	read/write	0
4.13	Reserved	Always returns 0, writes ignored	returns 0	0
4.12	Duplex Mode	1= Full Duplex 0 = Half Duplex	read/write	0
4.11:10	Speed	11 = Reserved 10 = 1 Gb/s 01 = 100 Mb/s 00 = 10 Mb/s	read/write	00
4.9:1	Reserved	Always return 0s	returns 0s	00000000
4.0	Reserved	Always returns 1	returns 1	1

Register 5: SGMII Auto-Negotiation Link Partner Ability



X13237

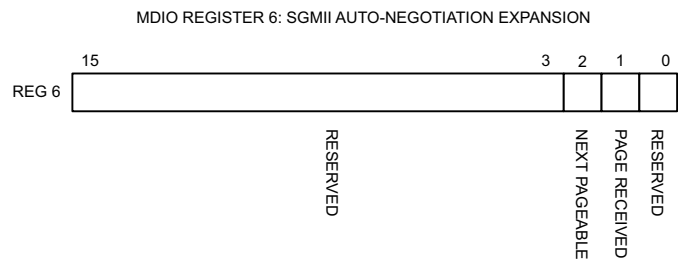
Figure 2-19: MDIO Register 5: SGMII Auto-Negotiation Link Partner Ability

The Auto-Negotiation Ability Base register (Register 5) contains information related to the status of the link between the PHY and its physical link partner across the Medium.

**Table 2-20: SGMII Auto-Negotiation Link Partner Ability Base (Register 5)**

Bits	Name	Description	Attributes	Default Value
5.15	PHY Link Status	This refers to the link status of the PHY with its link partner across the Medium. 1 = Link Up 0 = Link Down	read only	1
5.14	Acknowledge	Used by Auto-Negotiation function to indicate reception of a link partner base or next page	read only	0
5.13	Reserved	Always returns 0, writes ignored	returns 0	0
5.12	Duplex Mode	1= Full Duplex 0 = Half Duplex	read only	0
5.11:10	Speed	11 = Reserved 10 = 1 Gb/s 01 = 100 Mb/s 00 = 10 Mb/s	read only	00
5.9:1	Reserved	Always return 0s	returns 0s	00000000
5.0	Reserved	Always returns 1	returns 1	1

**Register 6: SGMII Auto-Negotiation Expansion**

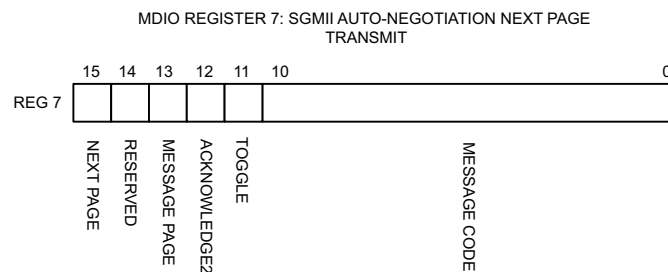


**Figure 2-20: MDIO Register 6: SGMII Auto-Negotiation Expansion**

**Table 2-21: SGMII Auto-Negotiation Expansion (Register 6)**

Bits	Name	Description	Attributes	Default Value
6.15:3	Reserved	Always return 0s	returns 0s	0000000000000
6.2	Next Page Able	This bit is ignored as the core currently does not support next page. This feature can be enabled on request.	returns 1	1
6.1	Page Received	1 = A new page has been received 0 = A new page has not been received	read only self clearing on read	0
6.0	Reserved	Always return 0s	returns 0s	0000000

**Register 7: SGMII Auto-Negotiation Next Page Transmit**



**Figure 2-21: MDIO Register 7: SGMII Auto-Negotiation Next Page Transmit**

**Table 2-22: SGMII Auto-Negotiation Next Page Transmit (Register 7)**

Bits	Name	Description	Attributes	Default Value <sup>(1)</sup>
7.15	Next Page	1 = Additional Next Page(s) to follow 0 = Last page	read/ write	0
7.14	Reserved	Always returns 0	returns 0	0
7.13	Message Page	1 = Message Page 0 = Unformatted Page	read/ write	1
7.12	Acknowledge 2	1 = Comply with message 0 = Cannot comply with message	read/ write	0
7.11	Toggle	Value toggles between subsequent Next Pages	read only	0

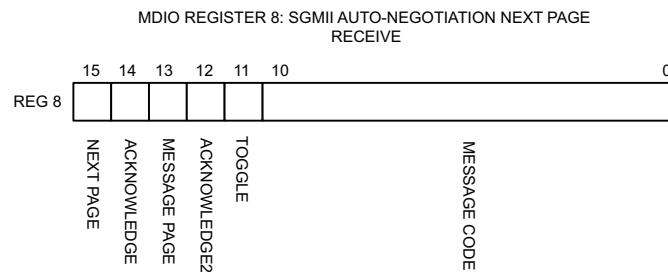
**Table 2-22: SGMII Auto-Negotiation Next Page Transmit (Register 7)**

Bits	Name	Description	Attributes	Default Value <sup>(1)</sup>
7.10:0	Message / Unformatted Code Field	Message Code Field or Unformatted Page Encoding as dictated by 7.13	read/write	0000000001 (Null Message Code)

**Notes:**

1. This register returns the default values because the core does not support next page. The feature can be enabled, if requested.

**Register 8: SGMII Next Page Receive**



**Figure 2-22: MDIO Register 8: SGMII Auto-Negotiation Next Page Receive**

**Table 2-23: SGMII Auto-Negotiation Next Page Receive (Register 8)**

Bits	Name	Description	Attributes	Default Value
8.15	Next Page	1 = Additional Next Page(s) to follow 0 = Last page	read only	0
8.14	Acknowledge	Used by Auto-Negotiation function to indicate reception of a link partner base or next page	read only	0
8.13	Message Page	1 = Message Page 0 = Unformatted Page	read only	0
8.12	Acknowledge 2	1 = Comply with message 0 = Cannot comply with message	read only	0
8.11	Toggle	Value toggles between subsequent Next Pages	read only	0
8.10:0	Message / Unformatted Code Field	Message Code Field or Unformatted Page Encoding as dictated by 8.13	read only	0000000000

**Register 15: SGMII Extended Status**

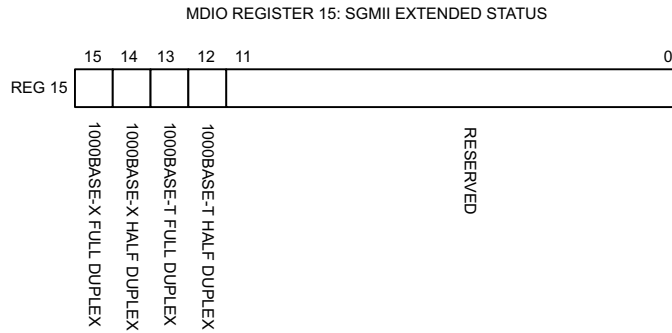


Figure 2-23: MDIO Register 15: SGMII Extended Status

Table 2-24: SGMII Extended Status (Register 15)

Bits	Name	Description	Attributes	Default Value
15.15	1000BASE-X Full Duplex	Always returns a 1 for this bit because 1000BASE-X Full Duplex is supported	returns 1	1
15.14	1000BASE-X Half Duplex	Always returns a 0 for this bit because 1000BASE-X Half Duplex is not supported	returns 0	0
15.13	1000BASE-T Full Duplex	Always returns a 0 for this bit because 1000BASE-T Full Duplex is not supported	returns 0	0
15.12	1000BASE-T Half Duplex	Always returns a 0 for this bit because 1000BASE-T Half Duplex is not supported	returns 0	0
15:11:0	Reserved	Always return 0s	returns 0s	000000000000

**Register 16: SGMII Auto-Negotiation Interrupt Control**

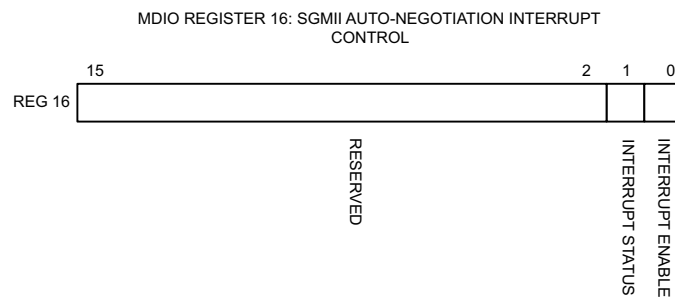


Figure 2-24: MDIO Register 16: SGMII Auto-Negotiation Interrupt Control

Table 2-25: SGMII Auto-Negotiation Interrupt Control (Register 16)

Bits	Name	Description	Attributes	Default Value
16.15:2	Reserved	Always return 0s	returns 0s	00000000000000
16.1	Interrupt Status	1 = Interrupt is asserted 0 = Interrupt is not asserted If the interrupt is enabled, this bit is asserted on completion of an Auto-Negotiation cycle across the SGMII link; it is only cleared by writing 0 to this bit. If the Interrupt is disabled, the bit is set to 0. <b>Note:</b> The an_interrupt port of the core is wired to this bit.	read/write	0
16.0	Interrupt Enable	1 = Interrupt enabled 0 = Interrupt disabled	read/write	1

**Register 18: SGMII Generic Control**

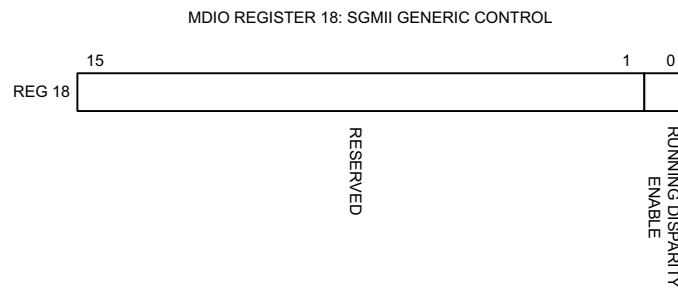


Figure 2-25: MDIO Register 18: SGMII Generic Control

Table 2-26: SGMII Generic Control (Register 18)

Bits	Name	Description	Attributes	Default Value
18.15:2	Reserved	Always return 0s	returns 0s	0000000000000000
18.1	GT Channel Valid	1 = Enabling contribution of status_vector[1] for data valid generation to RX FSM for the channel. 0 = Disabling contribution of status_vector[1] for data valid generation to RX FSM for the channel. <b>Note:</b> This register bit is valid only for 7 series devices.	read/write	1
18.0	Running Disparity Enable	1 = Running Disparity Checking enabled 0 = Running Disparity Checking disabled	read/write	0

### QSGMII Without Optional Auto-Negotiation

The registers provided are duplicated for each instance of the SGMII module in this core. The registers provided for SGMII operation in this core are adaptations of those defined in clauses 22 and 37 of the *IEEE 802.3-2008 Specification* [Ref 2]. In a QSGMII implementation, two different types of links exist. They are the QSGMII link between the MAC and PHY (QSGMII link) and the link across the Ethernet Medium itself (Medium). Information about the state of the QSGMII link is available in the registers that are described in this section.

The state of the link across the Ethernet Medium itself is not directly available when QSGMII Auto-Negotiation is not present. For this reason, the status of the link and the results of the PHYs Auto-Negotiation (for example, Speed and Duplex mode) must be obtained directly from the management interface of the connected PHY module. Registers at undefined addresses are read-only and return 0s.

Table 2-27: MDIO Registers for SGMII without Optional Auto-Negotiation

Register Address	Register Name
0	SGMII Control register
1	SGMII Status register
2, 3	PHY Identifier
15	SGMII Extended Status register
18	SGMII Generic Control

### Register 0: SGMII Control Register

Management Registers Channel/Module 0

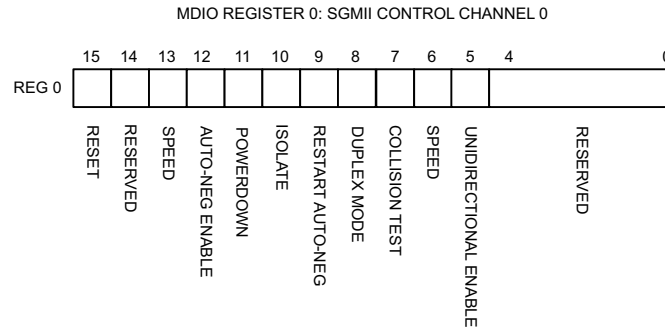


Figure 2-26: MDIO Register 0: SGMII Control Register Channel/Module 0

Table 2-28: SGMII Control Register Channel/Module 0 (Register 0)

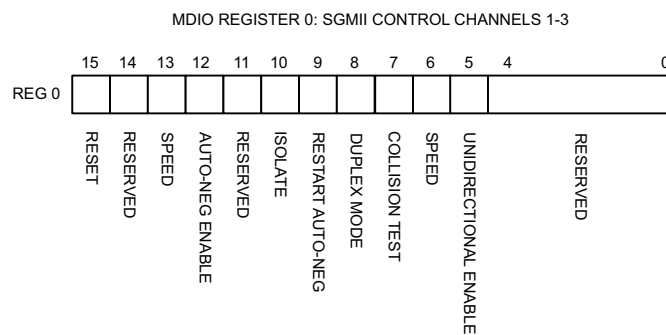
Bits	Name	Description	Attributes	Default Value
0.15	Reset	1 = SGMII module 0 Reset 0 = Normal Operation	read/write self clearing	0
0.14	Reserved	Returns what is written	read/write	0
0.13	Speed Selection (LSB)	Always returns a 0 for this bit. Together with bit 0.6, speed selection of 1000 Mb/s is identified.	returns 0	0
0.12	Auto-Negotiation Enable	1 = Enable SGMII Auto-Negotiation Process 0 = Disable SGMII Auto-Negotiation Process	read/write	1
0.11	Power Down	1 = Power down 0 = Normal operation When set to 1, the device-specific transceiver is placed in a low-power state. This bit requires a reset (see bit 0.15) to clear.	read/ write	0
0.10	Isolate	1 = Electrically Isolate SGMII logic from GMII 0 = Normal operation	read/write	1
0.9	Restart Auto-Negotiation	1 = Restart Auto-Negotiation Process across SGMII link 0 = Normal Operation	read/write self clearing	0
0.8	Duplex Mode	Always returns a 1 for this bit to signal Full-Duplex Mode.	returns 1	1
0.7	Collision Test	Always returns a 0 for this bit to disable COL test.	returns 0	0



**Table 2-28: SGMII Control Register Channel/Module 0 (Register 0) (Cont'd)**

Bits	Name	Description	Attributes	Default Value
0.6	Speed Selection (MSB)	Always returns a 1 for this bit. Together with bit 0.13, speed selection of 1000 Mb/s is identified.	returns 1	1
0.5	Unidirectional Enable	Enable transmit regardless of whether a valid link has been established provided AN is disabled.	read/write	0
0.4:0.0	Reserved	Always return 0s, writes ignored.	returns 0s	00000

Management Registers Channels/Modules 1-3



**Figure 2-27: MDIO Register 0: SGMII Control Channels/Modules 1-3**

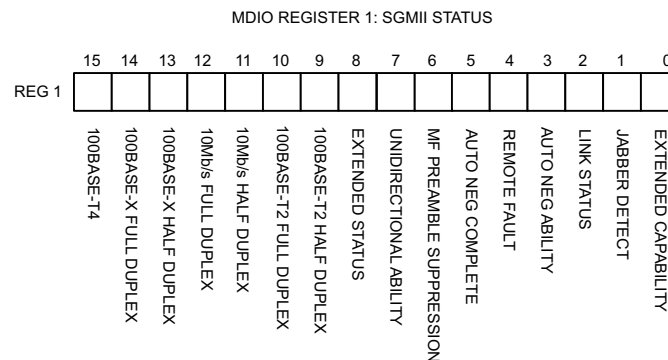
**Table 2-29: SGMII Control Register Channels/Modules 1-3 (Register 0)**

Bits	Name	Description	Attributes	Default Value
0.15	Reset	1 = SGMII module 1-3 Reset 0 = Normal Operation	read/write self clearing	0
0.14	Reserved	Returns what is written	read/write	0
0.13	Speed Selection (LSB)	Always returns a 0 for this bit. Together with bit 0.6, speed selection of 1000 Mb/s is identified.	returns 0	0
0.12	Auto-Negotiation Enable	1 = Enable SGMII Auto-Negotiation Process 0 = Disable SGMII Auto-Negotiation Process	read/write	1
0.11	Reserved	Returns what is written	read/ write	0
0.10	Isolate	1 = Electrically Isolate SGMII logic from GMII 0 = Normal operation	read/write	1

**Table 2-29: SGMII Control Register Channels/Modules 1-3 (Register 0) (Cont'd)**

Bits	Name	Description	Attributes	Default Value
0.9	Restart Auto-Negotiation	1 = Restart Auto-Negotiation Process across SGMII link 0 = Normal Operation	read/write self clearing	0
0.8	Duplex Mode	Always returns a 1 for this bit to signal Full-Duplex Mode	returns 1	1
0.7	Collision Test	Always returns a 0 for this bit to disable COL test	returns 0	0
0.6	Speed Selection (MSB)	Always returns a 1 for this bit. Together with bit 0.13, speed selection of 1,000 Mb/s is identified.	returns 1	1
0.5	Unidirectional Enable	Enable transmit regardless of whether a valid link has been established provided AN is disabled	read/write	0
0.4:0.0	Reserved	Always return 0s, writes ignored	returns 0s	00000

**Register 1: SGMII Status Register**



**Figure 2-28: MDIO Register 1: SGMII Status Register**

**Table 2-30: SGMII Status Register (Register 1)**

Bits	Name	Description	Attributes	Default Value
1.15	100BASE-T4	Always returns a 0 for this bit because 100BASE-T4 is not supported	returns 0	0
1.14	100BASE-X Full Duplex	Always returns a 0 for this bit because 100BASE-X Full Duplex is not supported	returns 0	0
1.13	100BASE-X Half Duplex	Always returns a 0 for this bit because 100BASE-X Half Duplex is not supported	returns 0	0
1.12	10 Mb/s Full Duplex	Always returns a 0 for this bit because 10 Mb/s Full Duplex is not supported	returns 0	0

Table 2-30: SGMII Status Register (Register 1) (Cont'd)

Bits	Name	Description	Attributes	Default Value
1.11	10 Mb/s Half Duplex	Always returns a 0 for this bit because 10 Mb/s Half Duplex is not supported	returns 0	0
1.10	100BASE-T2 Full Duplex	Always returns a 0 for this bit because 100BASE-T2 Full Duplex is not supported	returns 0	0
1.9	100BASE-T2 Half Duplex	Always returns a 0 for this bit because 100BASE-T2 Half Duplex is not supported	returns 0	0
1.8	Extended Status	Always returns a 1 for this bit to indicate the presence of the Extended register (Register 15)	returns 1	1
1.7	Unidirectional Ability	Always returns 1, writes ignored	returns 1	1
1.6	MF Preamble Suppression	Always returns a 1 for this bit to indicate that Management Frame Preamble Suppression is supported	returns 1	1
1.5	Auto-Negotiation Complete	1 = Auto-Negotiation process completed across SGMII link 0 = Auto-Negotiation process not completed across SGMII link	read only	0
1.4	Remote Fault	1 = A fault on the Medium has been detected 0 = No fault of the Medium has been detected	read only self clearing on read	0
1.3	Auto-Negotiation Ability	Always returns a 1 for this bit to indicate that the SGMII core is capable of Auto-Negotiation	returns 1	1
1.2	SGMII Link Status	1 = SGMII Link is up 0 = SGMII Link is down Latches 0 if the SGMII Link Status goes down. Clears to current SGMII Link Status on read. See the following <a href="#">Link Status</a> section for further details.	read only self clearing on read	0
1.1	Jabber Detect	Always returns a 0 for this bit because Jabber Detect is not supported	returns 0	0
1.0	Extended Capability	Always returns a 0 for this bit because no extended register set is supported	returns 0	0

### Link Status

When High, the link is valid and has remained valid after this register was last read; synchronization of the link has been obtained and Auto-Negotiation (if enabled) has completed.

When Low, either:

- A valid link has not been established; link synchronization has failed or Auto-Negotiation (if enabled) has failed to complete.

OR

- Link synchronization was lost at some point because this register was previously read. However, the current link status might be good. Therefore read this register a second time to get confirmation of the current link status.

Regardless of whether Auto-Negotiation is enabled or disabled, there can be some delay in the deassertion of Link Status following the loss of synchronization of a previously successful link. This is due to the Auto-Negotiation state machine which requires that synchronization is lost for an entire link timer duration before changing state. For more information, see the *802.3-2008 Specification* [Ref 2] (the `an_sync_status` variable).

**Registers 2 and 3 (PHY IDENTIFIER)**

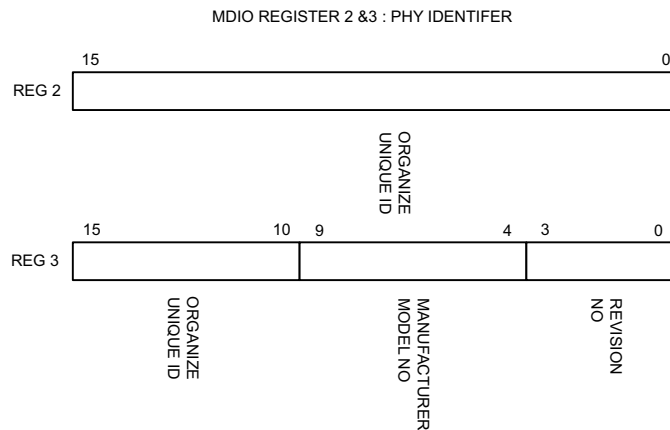


Figure 2-29: MDIO Register 2 and 3: PHY Identifier

Table 2-31: PHY Identifier (Registers 2 and 3)

Bits	Name	Description	Attributes	Default Value
2.15:0	Organizationally Unique Identifier	Always return 0s	returns 0s	0000000000000000
3.15:10	Organizationally Unique Identifier	Always return 0s	returns 0s	000000
3.9:4	Manufacturer model number	Always return 0s	returns 0s	000000
3.3:0	Revision Number	Always return 0s	returns 0s	0000

**Register 15: SGMII Extended Status**

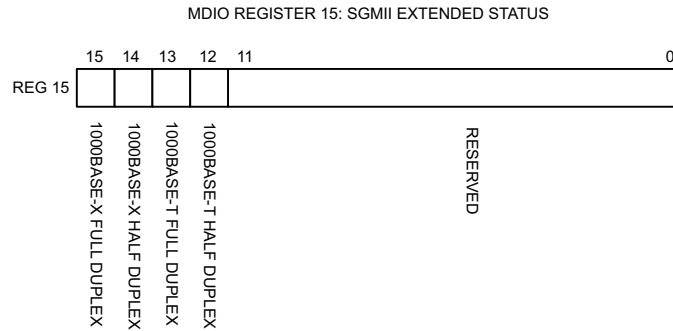


Figure 2-30: MDIO Register 15: SGMII Extended Status

Table 2-32: SGMII Extended Status (Register 15)

Bits	Name	Description	Attributes	Default Value
15.15	1000BASE-X Full Duplex	Always returns a 1 for this bit because 1000BASE-X Full Duplex is supported	returns 1	1
15.14	1000BASE-X Half Duplex	Always returns a 0 for this bit because 1000BASE-X Half Duplex is not supported	returns 0	0
15.13	1000BASE-T Full Duplex	Always returns a 0 for this bit because 1000BASE-T Full Duplex is not supported	returns 0	0
15.12	1000BASE-T Half Duplex	Always returns a 0 for this bit because 1000BASE-T Half Duplex is not supported	returns 0	0
15:11:0	Reserved	Always return 0s	returns 0s	000000000000

**Register 18: SGMII Generic Control (Register 18)**

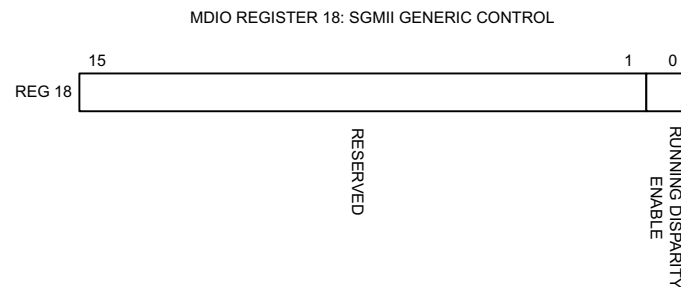


Figure 2-31: MDIO Register 18: SGMII Generic Control

Table 2-33: SGMII Generic Control (Register 18)

Bits	Name	Description	Attributes	Default Value
18.15:2	Reserved	Always return 0s	returns 0s	0000000000000000
18.1	GT Channel Valid	<p>1 = Enabling contribution of status_vector[1] for data valid generation to RX FSM for the channel.</p> <p>0 = Disabling contribution of status_vector[1] for data valid generation to RX FSM for the channel.</p> <p><b>Note:</b> This register bit is valid only for 7 series devices.</p>	read/write	1
18.0	Running Disparity Enable	<p>1 = Running Disparity Checking enabled</p> <p>0 = Running Disparity Checking disabled</p>	read/write	0

# Designing with the Core

This chapter provides an introduction about creating your own designs using the QSGMII core.

---

## Design Guidelines

### Understand the Core Netlist Features and Interfaces

[Chapter 1, Overview](#) introduces the features and [Chapter 2, Product Specification](#) introduces the interfaces and registers that are present in the logic of the QSGMII netlist. This chapter assumes a working knowledge of the *IEEE 802.3-2008* Ethernet specification [[Ref 2](#)], in particular the Gigabit Ethernet 100BASE-X sections: clauses 34 through to 37 and SGMII and QSGMII Cisco Specifications.

### Customize and Generate the Core

Generate the core with your desired options using the Vivado® IP catalog as described in [Chapter 6, Customizing and Generating the Core](#).

### Examine the Example Design

An HDL example design built around the core is provided through the Vivado design tools that allows for a demonstration of core functionality using either a simulation package or in hardware if placed on a suitable board.

Example designs are provided depending upon the core customization options that have been selected. See [Chapter 7, Example Design](#).

Before implementing the core in your application, examine the example design provided with the core to identify the steps that can be performed:

1. Edit the HDL top-level of the example design file to change the clocking scheme, add or remove IOBs as required
2. Synthesize the entire design.

3. Implement the entire design.  
After implementation is complete, you can also create a bitstream that can be downloaded to a Xilinx® device.
4. Download the bitstream to a target device.

## Implement the QSGMII Core in Your Application

Before implementing your application, examine the example design delivered with the core for information about the following:

- Instantiating the core from HDL
- Connecting the physical-side interface of the core
- Deriving the clock management logic

It is expected that the block-level module from the example design is instantiated directly into customer designs rather than the core netlist itself. The block level contains the core and a completed physical interface.

### *Write an HDL Application*

After reviewing the example design delivered with the core, write an HDL application that uses single or multiple instances of the block level module for the QSGMII core.

### *Synthesize your Design and Create a Bitstream*

Synthesize your entire design using the desired synthesis tool. Carefully constrain the design correctly; the constraints provided with the core should be used as the basis for your own. See the constraint chapters in the Vivado Design Suite as appropriate.

### *Simulate and Download your Design*

After creating a bitstream that can be downloaded to a Xilinx device, simulate the entire design and download it to the desired device.

### *Know the Degree of Difficulty*

An QSGMII core is challenging to implement in any technology and as such, all QSGMII core applications require 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 to increase system performance in an FPGA design, keep all inputs and outputs registered between the user application and the core. All inputs and outputs from the user 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 tools to place and route the design.

### ***Recognize Timing Critical Signals***

The constraints provided with the example design for the core identifies the critical signals and the timing constraints that should be applied. See [Constraining the Core in Chapter 6](#).

### ***Make Only Allowed Modifications***

The QSGMII core should not be modified. Modifications can have adverse effects on system timing and protocol compliance. Supported user configurations of the QSGMII core can only be made by selecting the options from within the Vivado design tools when the core is generated. See the Vivado IP catalog — [Customizing and Generating the Core in Chapter 6](#).

## **Shared Logic**

Up to version 2 of the QSGMII core, the RTL hierarchy for the core was fixed. This resulted in some difficulty because shareable clocking and reset logic needed to be extracted from the core example design for use with a single instance or multiple instances of the core.

Shared logic is a new feature that provides a more flexible architecture that works both as a standalone core and as a 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 to address more uses of the core.

The new level of hierarchy is called `<component_name>_support`. [Figure 3-1](#) and [Figure 3-2](#) show two hierarchies where the shared logic block is contained either 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 Vivado IDE (see [Figure 6-3](#)).

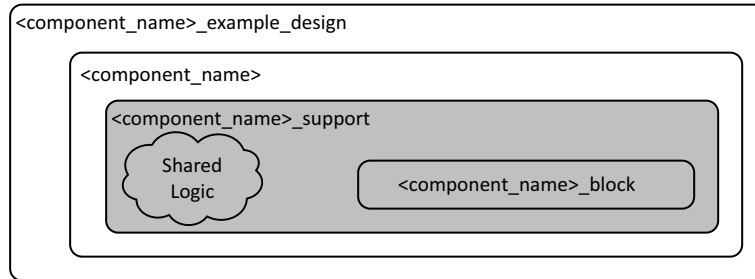


Figure 3-1: Shared Logic Included in Core

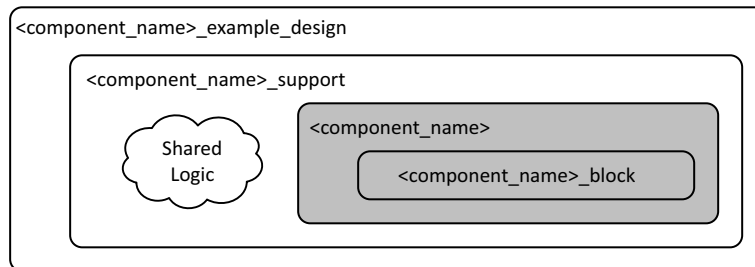


Figure 3-2: Shared Logic Included in Example Design

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## Clocking

- For clocking constraints see [Constraining the Core in Chapter 6](#).
  - For clocking information on client interface, see [Clock Generation Module in Chapter 4](#).
  - For clocking information on transceiver interface, see [Chapter 5, Using the Transceiver](#).
- 

## Resets

Because of the number of clock domains, the reset structure is not simple and involves several separate reset regions, with the number of regions being dependent upon the particular parameterization of the core. [Figure 3-3](#) shows the most common reset structure for the core.

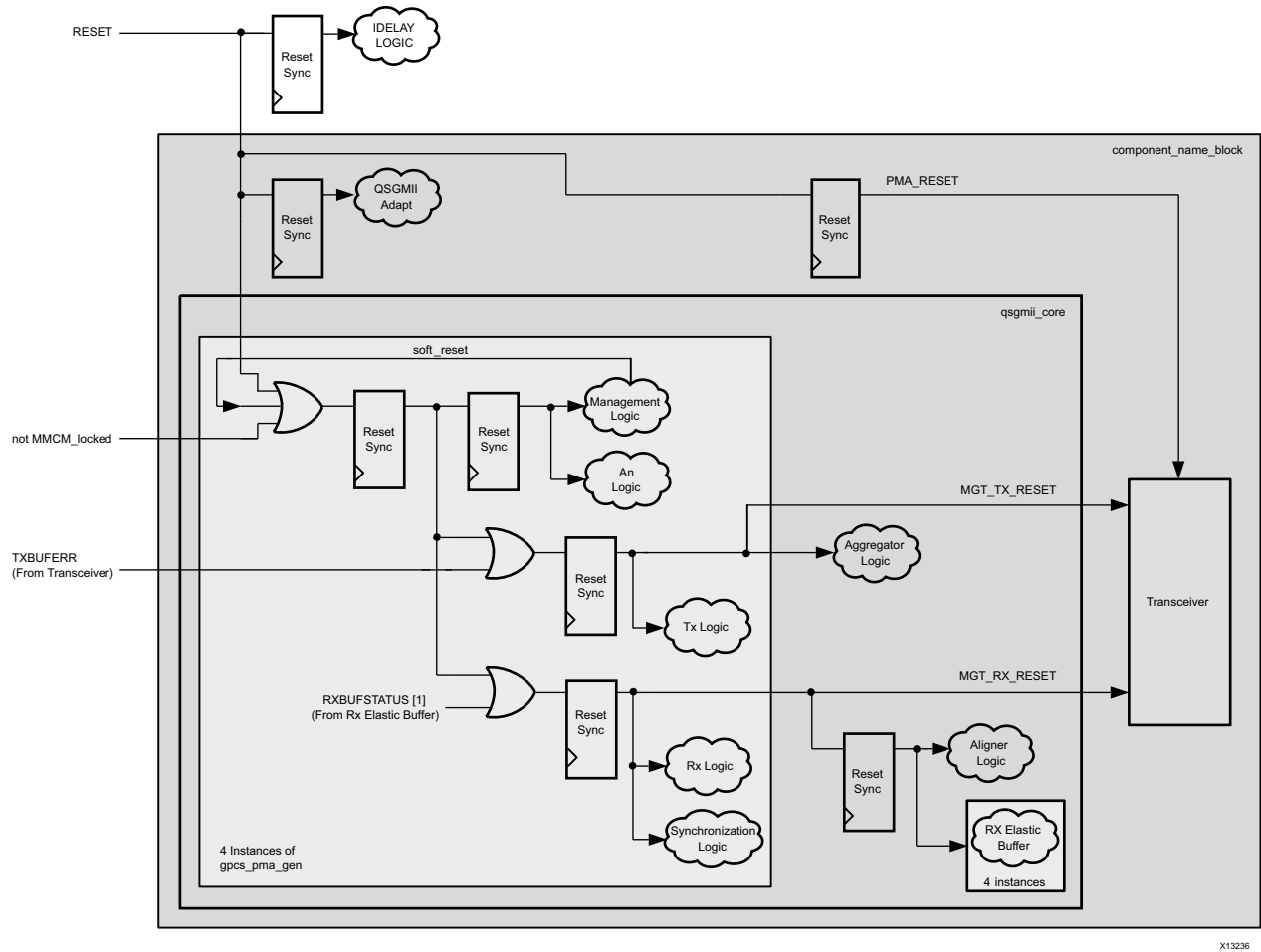


Figure 3-3: Reset Structure

# Using the Client Side GMII/MII Datapath

This chapter provides general guidelines for using the client-side instances of GMII/MII interfaces of the QSGMII core. In most applications, the client-side GMII is expected to be used as an internal interface connecting to either:

- Proprietary customer logic

This chapter describes the GMII-styled interface that is present on the netlist of the core.

The chapter then also focuses on additional adaptation logic (which is provided by the example design delivered with the core). This logic enhances the internal GMII-styled interface to support 10 Mb/s and 100 Mb/s Ethernet speeds in addition to the nominal 1 Gb/s speed of SGMII.

- The Xilinx® LogiCORE™ IP Tri-Mode Ethernet MAC

The QSGMII core can be integrated in a single device with multiple instances of the Xilinx LogiCORE IP Tri-Mode Ethernet MAC core to extend the system functionality to include the MAC sublayer. See the “Interfacing to Other Cores” section in the “Designing with the Core” chapter in the *1G/2.5G Ethernet PCS/PMA or SGMII LogiCORE IP Product Guide* (PG047) [Ref 5].



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**CAUTION!** *The TEMAC core should always be configured for full-duplex operation when used with the QSGMII core. This constraint is due to the increased latency introduced by the QSGMII core. With half-duplex operation, the MAC response to collisions is late, violating the Code-Division Multiple Access (CDMA) protocol.*

---

In rare applications, the Client-Side GMII datapath can be used as a true GMII/MII to connect externally off-chip across a PCB. This external GMII functionality is included in the HDL example design delivered with the core by the Vivado® design tools to act as an illustration. The extra logic required to create a true external GMII is detailed in [Appendix C, Implementing External GMII/MII](#).

# Using the Encrypted Core Level Client-Side GMII/MII

## GMII Transmission

This section includes figures that illustrate GMII transmission. In these figures, the clock is not labeled. The source of this clock signal varies, depending on the options selected when the core is generated.

### Normal Frame Transmission

Normal outbound frame transfer timing is illustrated in [Figure 4-1](#). This figure shows that an Ethernet frame is preceded by an 8-byte preamble field (inclusive of the Start of Frame Delimiter (SFD), and completed with a 4-byte Frame Check Sequence (FCS) field. This frame is created by the MAC connected to the other end of the GMII. The PCS logic does not recognize the different fields within a frame and treats any value placed on `gmii_txd_chx[7:0]` within the `gmii_tx_en_chx` assertion window as data.

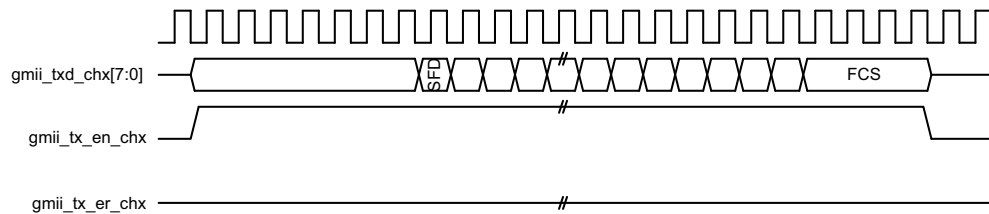


Figure 4-1: GMII Normal Frame Transmission

### Error Propagation

A corrupted frame transfer is illustrated in [Figure 4-2](#). An error can be injected into the frame by asserting `gmii_tx_er_chx` at any point during the `gmii_tx_en_chx` assertion window. The core ensures that all errors are propagated through both transmit and receive paths so that the error is eventually detected by the link partner.

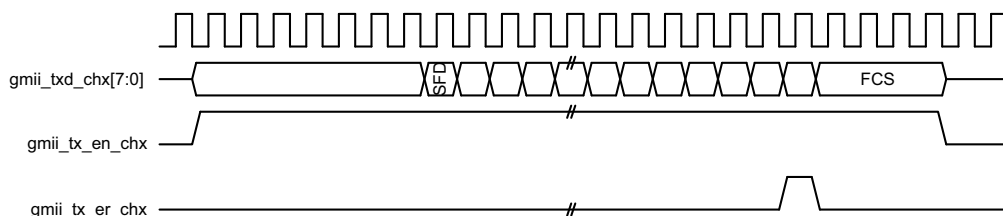


Figure 4-2: GMII Error Propagation Within a Frame

## GMII Reception

This section includes figures that illustrate GMII reception. In these figures, the clock is not labeled. The source of this clock signal varies, depending on the options used when the core is generated.

### Normal Frame Reception

The timing of normal inbound frame transfer is illustrated in [Figure 4-3](#). This shows that Ethernet frame reception is preceded by a preamble field. The *IEEE 802.3-2008 Specification* [Ref 2] (see clause 35) allows for up to all of the seven preamble bytes that proceed the Start of Frame Delimiter (SFD) to be lost in the network. The SFD is always present in well-formed frames.

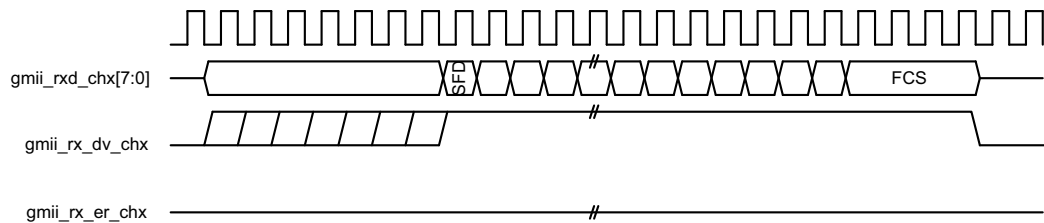


Figure 4-3: GMII Normal Frame Reception

### Normal Frame Reception with Extension Field

In accordance with the *IEEE 802.3-2008 Specification* [Ref 2], clause 36, state machines for the 1000BASE-X PCS, `gmii_rx_er_chx` can be driven High following reception of the end frame in conjunction with `gmii_rxd_chx[7:0]` containing the hexadecimal value of 0x0F to signal carrier extension. This is illustrated in [Figure 4-4](#).

This is not an error condition and can occur even for full-duplex frames.

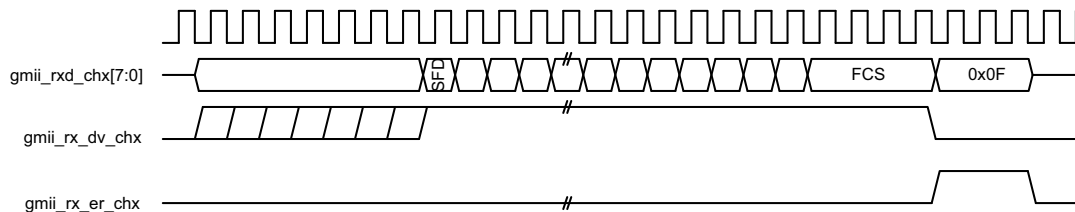


Figure 4-4: GMII Normal Frame Reception with Carrier Extension

## Frame Reception with Errors

The signal `gmii_rx_er_chx` when asserted within the assertion window signals that a frame was received with a detected error (Figure 4-5). In addition, a late error can also be detected during the Carrier Extension interval. This is indicated by `gmii_rxd_chx[7:0]` containing the hexadecimal value `0x1F`, also illustrated in Figure 4-5.

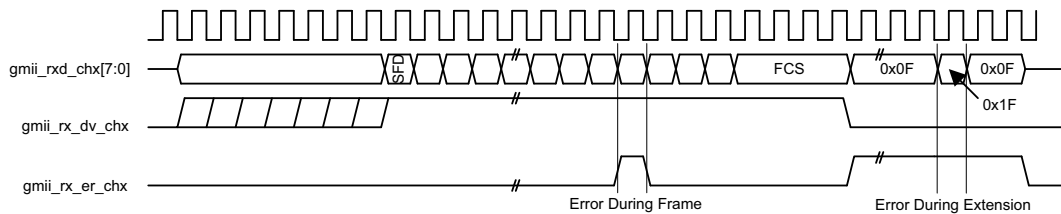


Figure 4-5: GMII Frame Reception with Errors

## MII Transmission

### 100 Mb/s Frame Transmission

The operation of the core remains unchanged. It is the responsibility of the client logic (for example, an Ethernet MAC) to enter data at the correct rate. When operating at a speed of 100 Mb/s, every byte of the MAC frame (from preamble field to the Frame Check Sequence field, inclusive) should each be repeated for 10 clock periods to achieve the desired bit rate, as illustrated in Figure 4-6. It is also the responsibility of the client logic to ensure that the interframe gap period is legal for the current speed of operation.

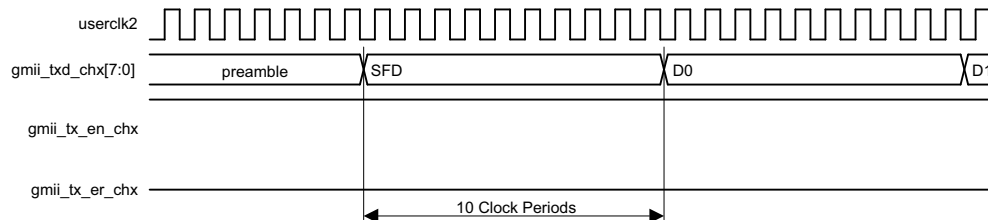


Figure 4-6: 100 Mb/s Frame Transmission

### 10 Mb/s Frame Transmission

The operation of the core remains unchanged. It is the responsibility of the client logic (for example, an Ethernet MAC), to enter data at the correct rate. When operating at a speed of 10 Mb/s, every byte of the MAC frame (from preamble to the frame check sequence field, inclusive) should each be repeated for 100 clock periods to achieve the desired bit rate. It is also the responsibility of the client logic to ensure that the interframe gap period is legal for the current speed of operation.

## MII Reception

### 100 Mb/s Frame Reception

The operation of the QSGMII core remains unchanged. When operating at a speed of 100 Mb/s, every byte of the MAC frame (from preamble to the frame check sequence field, inclusive) is repeated for 10 clock periods to achieve the desired bit rate. See Figure 4-7. It is the responsibility of the client logic, for example an Ethernet MAC, to sample this data correctly.

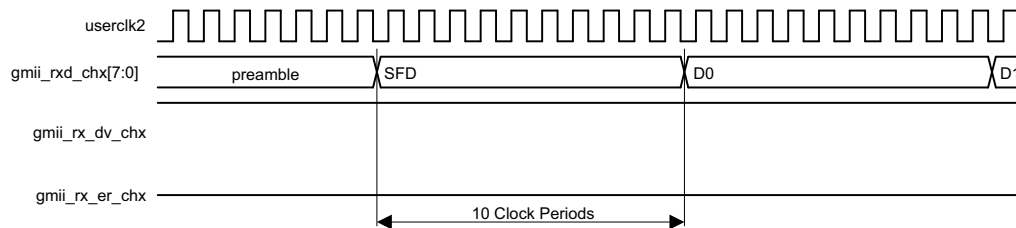


Figure 4-7: 100 Mb/s Frame Reception

### 10 Mb/s Frame Reception

The operation of the core remains unchanged. When operating at a speed of 10 Mb/s, every byte of the MAC frame (from preamble to the frame check sequence field, inclusive) is repeated for 100 clock periods to achieve the desired bit rate. It is the responsibility of the client logic (for example, an Ethernet MAC) to sample this data correctly.



## Additional Client-Side QSGMII Adaptation Logic

The block level of the core contains the QSGMII Adaptation Module (this is illustrated in [Figure 4-8](#)). This QSGMII adaptation module is described in the remainder of this section.

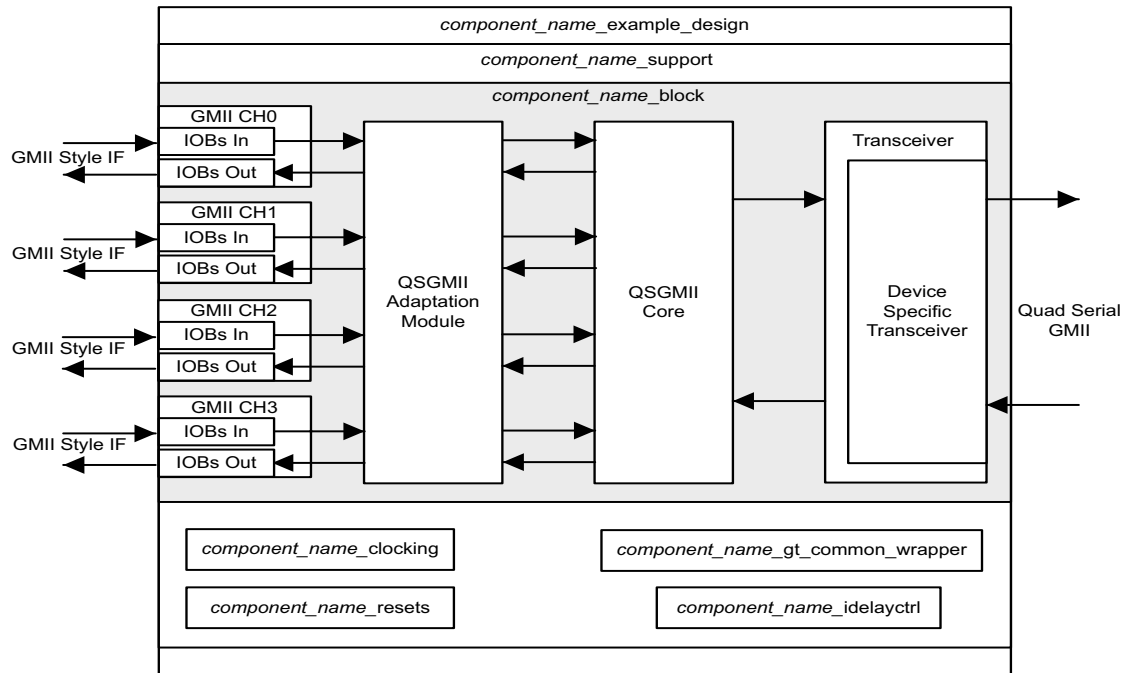


Figure 4-8: Example Design HDL for QSGMII

Because the GMII of the core always operates at 125 MHz, the core makes no differentiation between the three QSGMII speeds of operation. It always effectively operates at 1 Gb/s. However, as described previously in [Using the Encrypted Core Level Client-Side GMII/MII](#), at 100 Mb/s, every data byte run through the core is repeated ten times to achieve the required bit rate; at 10 Mb/s, each data byte run through the core is repeated 100 times to achieve the required bit rate. Dealing with this repetition of bytes is the function of the QSGMII adaptation module. In addition in PHY mode and operating in MII, the QSGMII adaptation module is also responsible for conversion of the 4-bit MII interface to an 8-bit GMII core interface.

The provided QSGMII adaptation module ([Figure 4-9](#)) creates a GMII interface that drives/samples the GMII data and control signals at the following frequencies:

- 125 MHz when operating at a speed of 1 Gb/s (with no repetition of data bytes).
- 12.5 MHz at a speed of 100 Mb/s (each data byte is repeated and run through the core 10 times).
- 1.25 MHz at a speed of 10 Mb/s (each data byte is repeated and run through the core 100 times).

Therefore, the result of the QSGMII adaptation module is to create a proprietary interface that is based on GMII (true GMII only operates at a clock frequency of 125 MHz). This interface then allows a straightforward internal connection to an Ethernet MAC core when operating in MAC mode or the GMII can be brought out on pads to connect to an external PHY when the core operates in PHY mode. For example, the QSGMII adaptation module can be used to interface to the QSGMII core, operating in MAC, to four instances of the Xilinx Tri-Mode Ethernet MAC core directly. The GMII interface of the QSGMII adaptation module can be brought out to the pads and connected to an external PHY module that converts GMII to PMD signals when the QSGMII core is operating in PHY mode.

## QSGMII Adaptation Module Top-Level

The QSGMII adaptation module contains four instances of the SGMII adaptation module with each instance corresponding to one channel as shown in Figure 4-9.

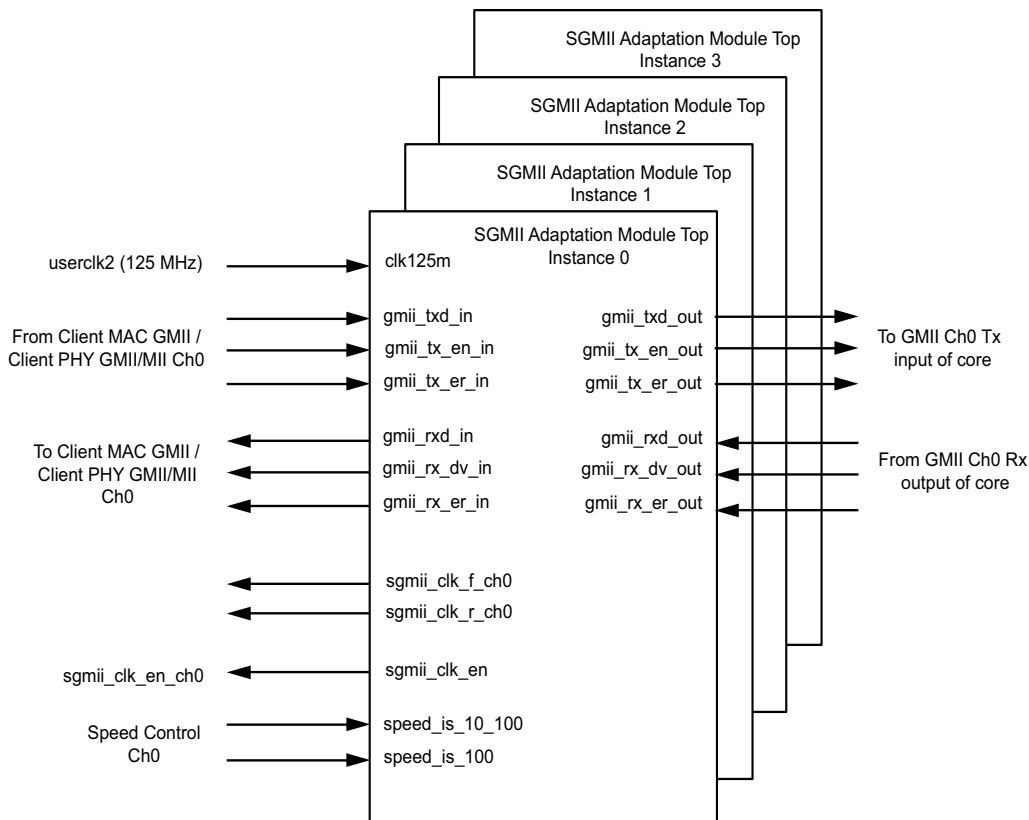


Figure 4-9: QSGMII Adaptation Module

### SGMII Adaptation Module Top-Level

The SGMII adaptation module is described in several hierarchical submodules as illustrated in Figure 4-10. These submodules are each described in separate HDL files and are described in the following sections.

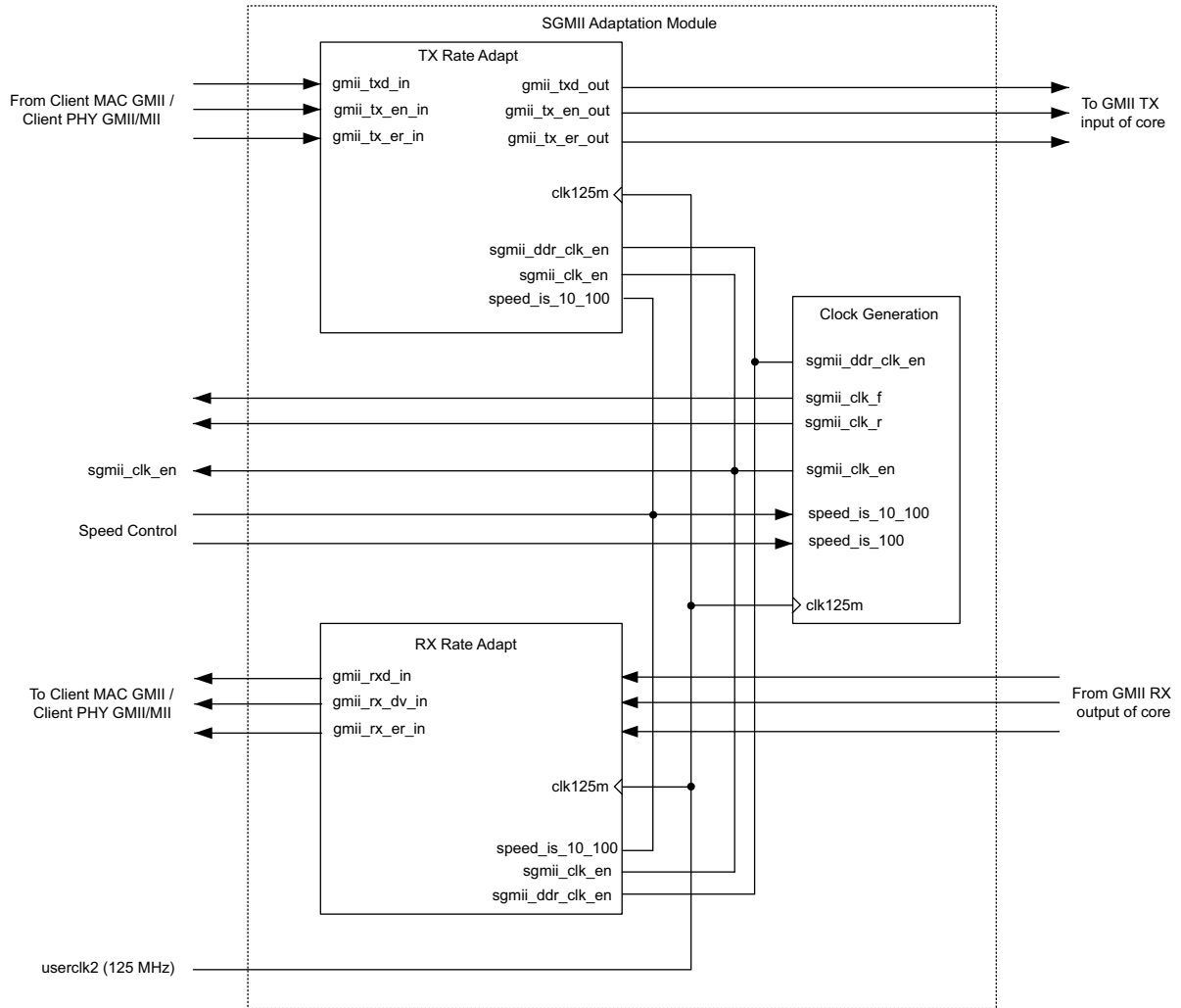


Figure 4-10: SGMII Adaptation Module

## Transmitter Rate Adaptation Module

### QSGMII Operating in MAC Mode

This module accepts transmitter data from the GMII-style interface from the attached client MAC and samples the input data on the 125 MHz reference clock, `clk125m`. This sampled data can then be connected directly to the input GMII instances of the QSGMII netlist. The 1 Gb/s and 100 Mb/s cases are illustrated in [Figure 4-11](#).

At all speeds, the client MAC logic should drive the GMII transmitter data synchronously to the rising edge of the 125 MHz reference clock while using `sgmmi_clk_en` (derived from the Clock Generation module) as a clock enable. The frequency of this clock enable signal ensures the correct data rate and correct data sampling between the two devices.

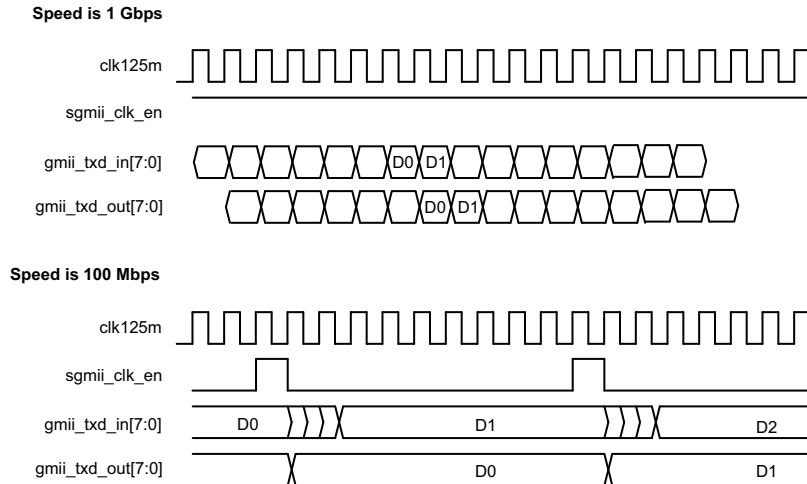


Figure 4-11: Transmitter Rate Adaptation Module Sampling in MAC Mode

### QSGMII Operating in PHY Mode

QSGMII in PHY mode follows the true GMII/MII interface. When the GMII interface is selected, the data is received on the 125 MHz clock (`clk125m`). When the MII interface is selected, 4 bits of MII are received on the least significant bit (LSB) 4 bits of the GMII interface. This interface is converted to 8 bits by sampling with `sgmii_ddr_clk_en` (derived from the Clock Generation module).

This 8-bit interface should drive the GMII transmitter data synchronously to the rising edge of the 125 MHz reference clock while using `sgmii_clk_en` (derived from the Clock Generation module) as a clock enable.

It is possible that the Start of Frame Delimiter (SFD) could have been skewed across two separate bytes, so 8-bit SFD code is detected, and if required, it is realigned across the 8-bit datapath.

The 1 Gb/s and 100 Mb/s cases are illustrated in [Figure 4-12](#).

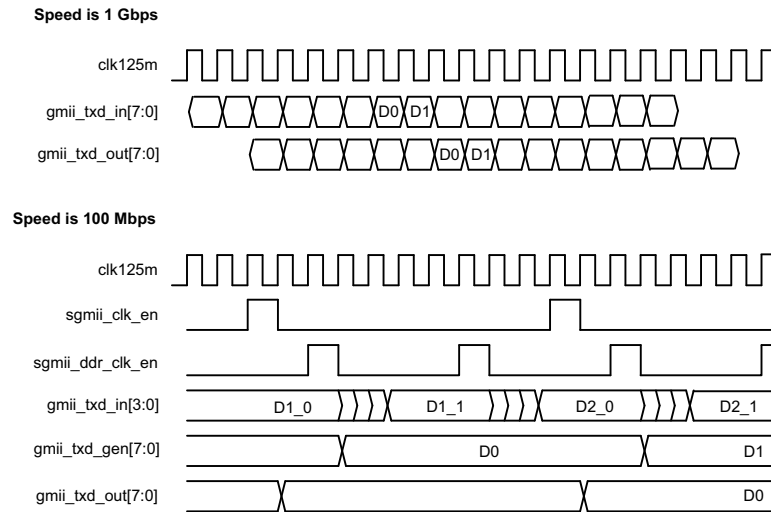


Figure 4-12: Transmitter Rate Adaptation Module Sampling in PHY Mode

## Receiver Rate Adaptation Module

### QSGMII Operating in MAC Mode

This module accepts received data from the QSGMII core. This data is sampled and sent out of the GMII receiver interface for the attached client MAC. The 1 Gb/s and 100 Mb/s cases are illustrated in [Figure 4-13](#).

At 1 Gb/s, the data is valid on every clock cycle of the 125 MHz reference clock (`clk125m`). Data received from the core is clocked straight through the Receiver Rate Adaptation module.

At 100 Mb/s, the data is repeated for a 10 clock period duration of `clk125m`; at 10 Mb/s, the data is repeated for a 100 clock period duration of `clk125m`. The Receiver Rate Adaptation Module samples this data using the `sgmiiclk_en` clock enable.

The Receiver Rate Adaptation module also performs a second function that accounts for the latency inferred in [Figure 4-13](#). The 8-bit SFD code is detected, and if required, it is realigned across the 8-bit datapath of `gmii_rxd_out[7:0]` before being presented to the attached client MAC. It is possible that this SFD could have been skewed across two separate bytes by MACs operating on a 4-bit datapath.

At all speeds, the client MAC logic should sample the GMII receiver data synchronously to the rising edge of the 125 MHz reference clock while using `sgmiiclk_en` (derived from the Clock Generation module) as a clock enable. The frequency of the `sgmiiclk_en` clock enable signal ensures the correct data rate and correct data sampling between the two devices.

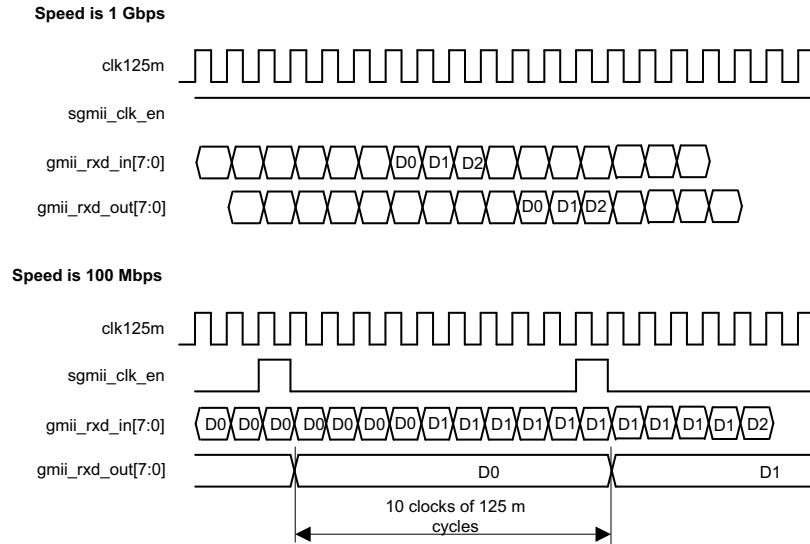


Figure 4-13: Receiver Rate Adaptation Module Sampling in MAC Mode

### QSGMII Operating in PHY Mode

This module accepts received data from the QSGMII core. This data is sampled and sent out of the GMII receiver interface for the attached external PHY. The 1 Gb/s and 100 Mb/s cases are illustrated in Figure 4-14.

At 1 Gb/s the data is valid on every clock cycle of the 125 MHz reference clock (`clk125m`). Data received from the core is clocked straight through the Receiver Rate Adaptation module.

At 100 Mb/s, the data is repeated for a 10 clock period duration of `clk125m`; at 10 Mb/s, the data is repeated for a 100 clock period duration of `clk125m`. The Receiver Rate Adaptation Module samples this data using the `sgmii_clk_en` clock enable. Then the lower half of the byte is sent on the LSB 4 bits of `gmii_rxd_out[3:0]` followed by the upper nibble. This operation is done on `sgmii_ddr_clk_en`.

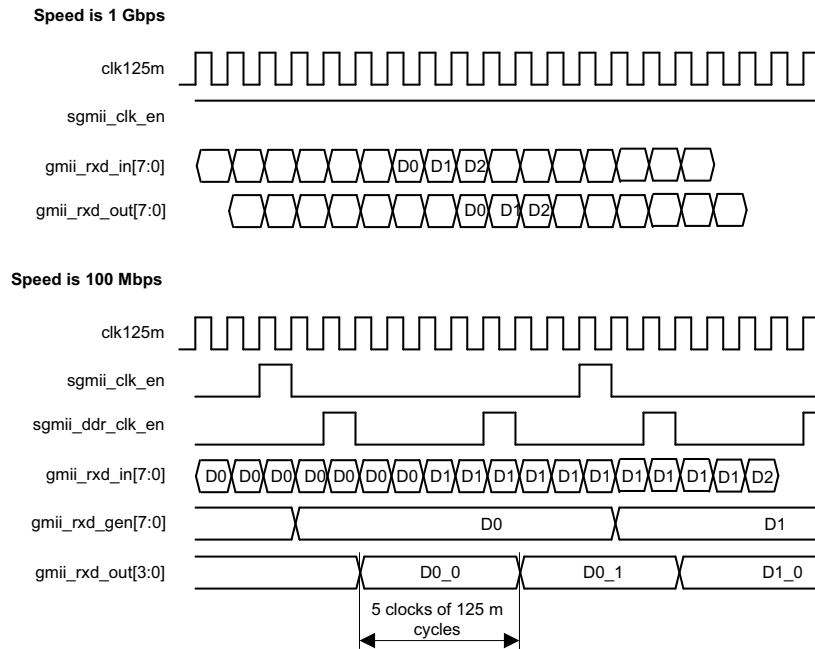


Figure 4-14: Receiver Rate Adaptation Module Sampling in PHY Mode

### Clock Generation Module

This module creates the `sgmiiclk_en` clock enable signal for use throughout the SGMII adaptation module.

Clock enabled frequencies are:

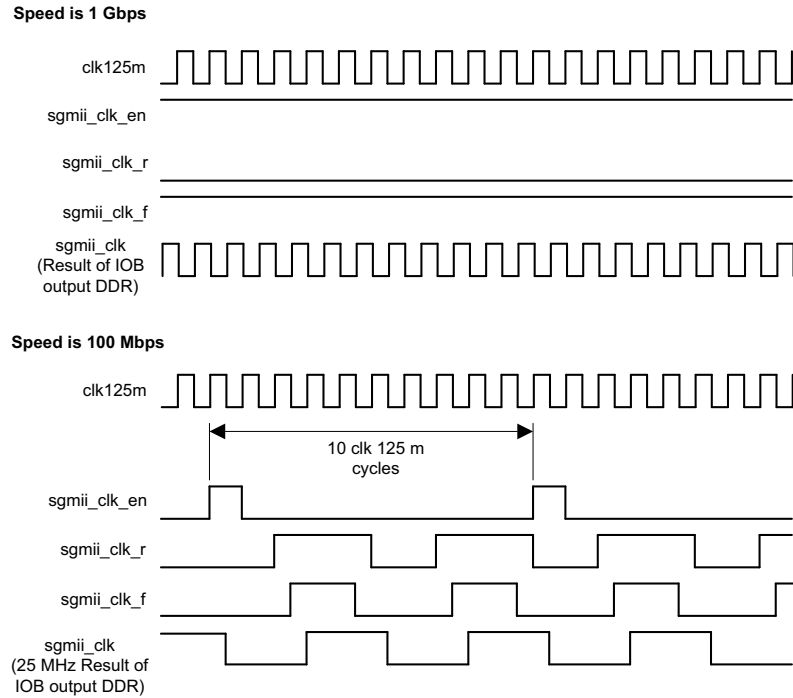
- 125 MHz at an operating speed of 1 Gb/s
- 12.5 MHz at an operating speed of 100 Mb/s
- 1.25 MHz at an operating speed of 10 Mb/s

This module also creates output clock `sgmiiclk_chx` from rise and fall clocks.

Clock generation rise and fall frequencies are:

- 125 MHz at an operating speed of 1 Gb/s in PHY mode and for all speeds in MAC mode
- 25 MHz at an operating speed of 100 Mb/s
- 2.5 MHz at an operating speed of 10 Mb/s

Figure 4-15 illustrates the output clock enable signal for the Clock Generation module at 1 Gb/s and 100 Mb/s speeds.



**Figure 4-15: Clock Generator Output Clock and Clock Enables**

Figure 4-15 also illustrates the formation of the `sgmiiclk_r` and `sgmiiclk_f` signals. These are used only in the example design delivered with the core, where they are routed to a device IOB DDR output register. This provides SGMII clock forwarding at the correct frequency.



# Using the Transceiver

This chapter provides general guidelines for using transceivers with UltraScale+™ families, UltraScale™ architecture, Zynq®-7000 All Programmable SoC, Virtex®-7, Kintex®-7, or Artix®-7 devices and is organized into the following main sections, with each section being organized into FPGA families.

- [Transceiver Logic](#)

Providing a more detailed look at the device-specific transceivers and their connections to the netlist of the core.

- [Clock Sharing Across Multiple Cores with Transceivers](#)

Providing guidance for using several cores and transceiver instantiations; clock sharing should occur whenever possible to save device resources.

---

## Transceiver Logic

The example is split between two discrete hierarchical layers, as illustrated in [Figure 5-1](#). The block level is designed so that it can be instantiated directly into customer designs and provides the following functionality:

- Instantiates the core from HDL.
- Connects the client interface through the QSGMII adaptation module. See [Chapter 4, Using the Client Side GMII/MII Datapath](#).
- Connects the physical-side interface of the core to an UltraScale+ families, UltraScale architecture, Zynq-7000 AP SoC, Virtex-7, Kintex-7, or Artix-7 device transceiver.

The logic implemented in the block level for the physical-side interface of the core is illustrated in all the figures and described in further detail for the remainder of this chapter.

## Virtex-7 Devices

The core is designed to integrate with the 7 series FPGA transceiver. [Figure 5-1](#) illustrates the connections and logic required between the core and the transceiver; the signal names and logic in the figure precisely match those delivered with the example design when a 7 series FPGA transceiver is used.

The 125 MHz differential reference clock is routed directly to the 7 series FPGA transceiver. The transceiver is configured to output a version of this clock (125 MHz) on the `txoutclk` port; this is then placed onto global clock routing and is input back into the transceiver on the user interface clock ports `txusrclk` and `txusrclk2`. This clock is also used to source for all core logic.

The transceiver is configured to output a recovered clock (125 MHz) on the `rxoutclk` port; this is placed onto regional routing through BUFMR and BUFR. This clock is then used to source the receive logic from the transceiver receive side output to the `rxelastic` buffer in the core. The clocking logic is included in a separate module `<component_name>_clocking` which is instantiated in the `<component_name>_support` module.

The two wrapper files immediately around the transceiver pair, `gtwizard` and `gtwizard_gt` ([Figure 5-1](#)), are generated from the 7 series FPGA transceiver wizard. These files apply all the QSGMII attributes. Consequently, these files can be regenerated by invoking the 7 series FPGAs transceivers wizard in the Vivado Design Suite and selecting the QSGMII Protocol template on the Line Rate, RefClk Selection tab. For more information, see the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [\[Ref 6\]](#).

**Note:** The optional Transceiver Control and Status ports are not shown here. These ports have been brought up to the `<component_name>` module level.

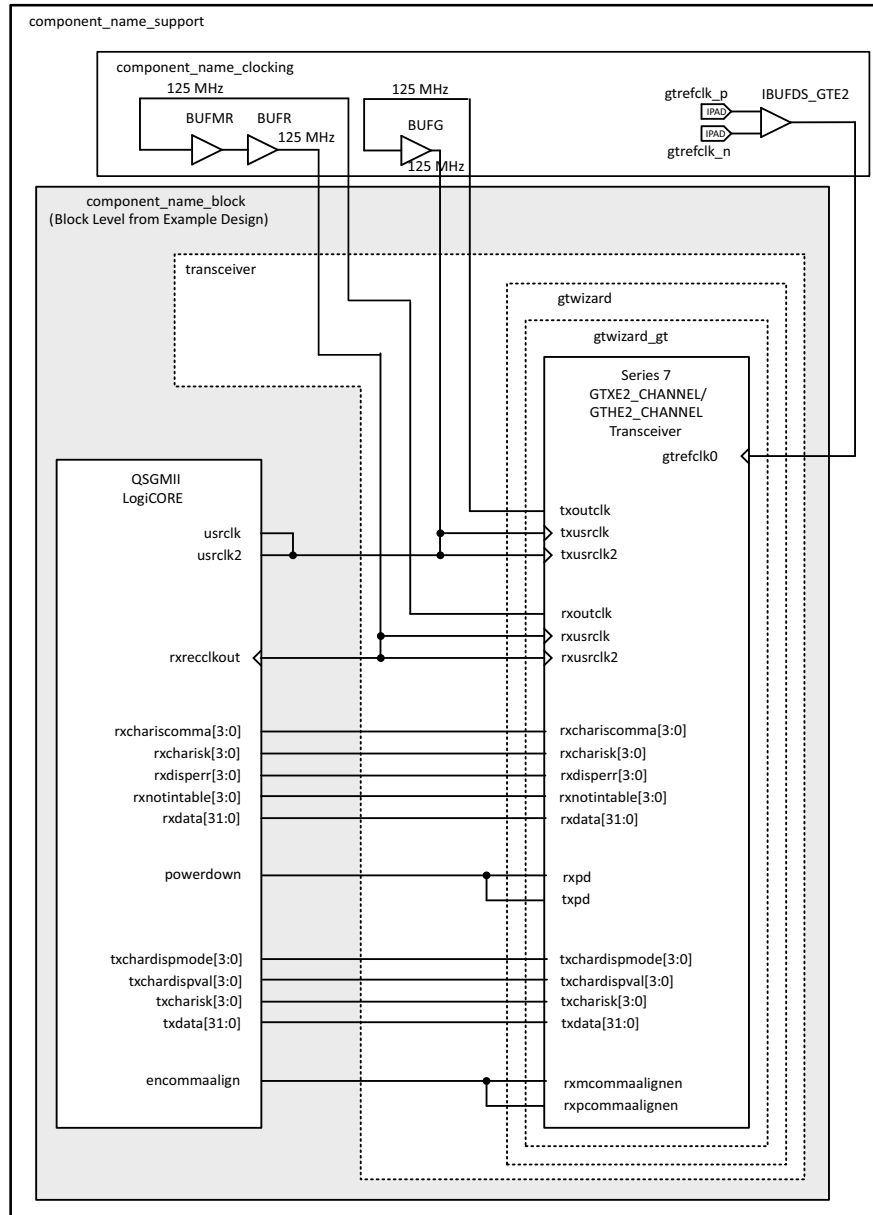


Figure 5-1: QSGMII Connection to Virtex-7 FPGA Transceivers

## Zynq-7000 AP SoC/Kintex-7 Devices

The core is designed to integrate with the 7 series FPGA transceiver. [Figure 5-2](#) illustrates the connections and logic required between the core and the transceiver; the signal names and logic in the figure precisely match those delivered with the example design when a 7 series FPGA transceiver is used.

The 125 MHz differential reference clock is routed directly to the 7 series transceiver. The transceiver is configured to output a version of this clock (125 MHz) on the `txoutclk` port; this is then placed onto global clock routing and is input back into the GTXE2 transceiver on the user interface clock ports `txusrclk` and `txusrclk2`. This clock is also used to source for all core logic.

The transceiver is configured to output a recovered clock (125 MHz) on the `rxoutclk` port; this is placed onto global routing through BUFG. This clock is then used to source the receive logic from Transceiver receive side output to the `rxelastic` buffer in the core. The clocking logic is included in a separate module, `<component_name>_clocking`, which is instantiated in the `<component_name>_support` module.

The two wrapper files immediately around the GTP transceiver pair, `gtwizard` and `gtwizard_gt` ([Figure 5-2](#)), are generated from the 7 series FPGA transceiver wizard. These files apply all the QSGMII attributes. Consequently, these files can be regenerated by invoking the 7 series FPGAs transceivers wizard in the Vivado Design Suite and selecting the QSGMII Protocol template on the Line Rate, RefClk Selection tab. For more information, see the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [\[Ref 6\]](#).

**Note:** The optional Transceiver Control and Status ports are not shown here. These ports have been brought up to the `<component_name>` module level.

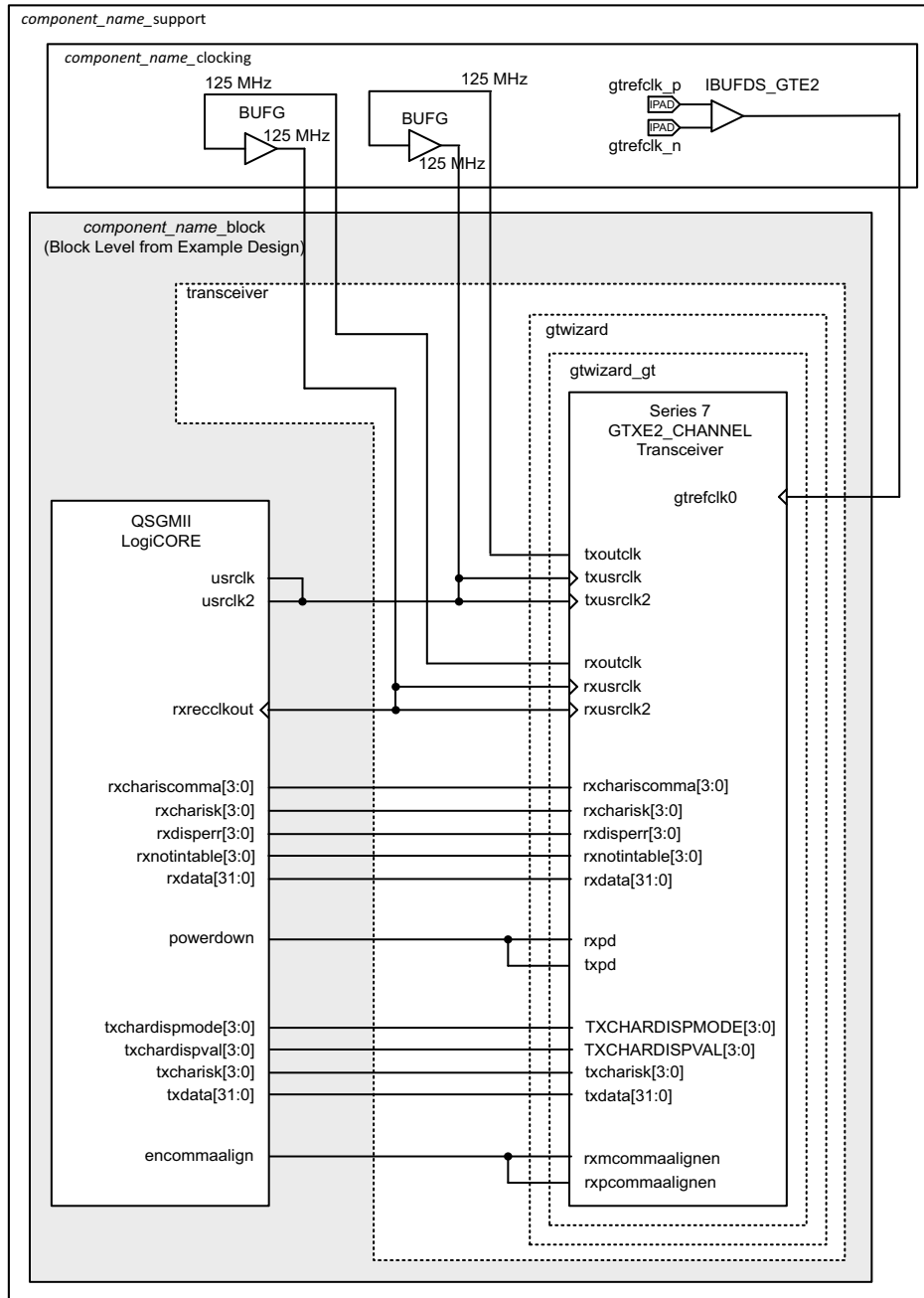


Figure 5-2: QSGMII Connection to Zynq-7000 AP SoC/Kintex-7 FPGA Transceivers

## Artix-7 Devices

The QSGMII core is designed to integrate with the 7 series FPGA transceiver. [Figure 5-3](#) illustrates the connections and logic required between the core and the transceiver; the signal names and logic in the figure precisely match those delivered with the example design when a 7 series FPGA transceiver is used.

The 125 MHz differential reference clock is routed directly to the 7 series transceiver. The transceiver is configured to output a version of this clock (125 MHz) on the `txoutclk` port; this is then placed onto global clock routing and passed to a MMCM which generates two clocks; one 125 MHz (`userclk2`) and other 250 MHz (`userclk`). The `userclk` and `userclk2` signals are input back into the GTPE2 transceiver on the user interface clock ports `txusrclk` and `txusrclk2`. The `userclk2` clock is also used to source for all core logic.

The transceiver is configured to output a recovered clock (250 MHz) on the `rxoutclk` port. This clock is divided down to 125 MHz using BUFR and is then used to source the receive logic from Transceiver receive side `rxelastic` buffer read in the core and `rxusrclk2` port of transceiver. The 250 MHz `rxoutclk` is placed on regional clock routing using BUFR and is routed back to `rxusrclk` port of transceiver. The clocking logic is included in separate module, `<component_name>_clocking`, which is instantiated in the `<component_name>_support` module. In [Figure 5-3](#), clocking resources BUFRM and BUFR are used on `rxoutclk`. In certain devices BUFRMs are not available. In this case, other clocking schemes need to be used with the core generated with the **Include Shared Logic in Example Design** option.

The two wrapper files immediately around the GTP transceiver pair, `gtwizard` and `gtwizard_gt` ([Figure 5-3](#)), are generated from the 7 series FPGA transceiver wizard. These files apply all the QSGMII attributes. Consequently, these files can be regenerated by invoking the 7 series FPGAs transceivers wizard in the Vivado Design Suite and selecting the QSGMII Protocol template on the Line Rate, RefClk Selection tab. For more information, see the *7 Series FPGAs GTP Transceivers User Guide* (UG482) [[Ref 7](#)].

**Note:** The optional Transceiver Control and Status ports are not shown here. These ports have been brought up to the `<component_name>` module level.

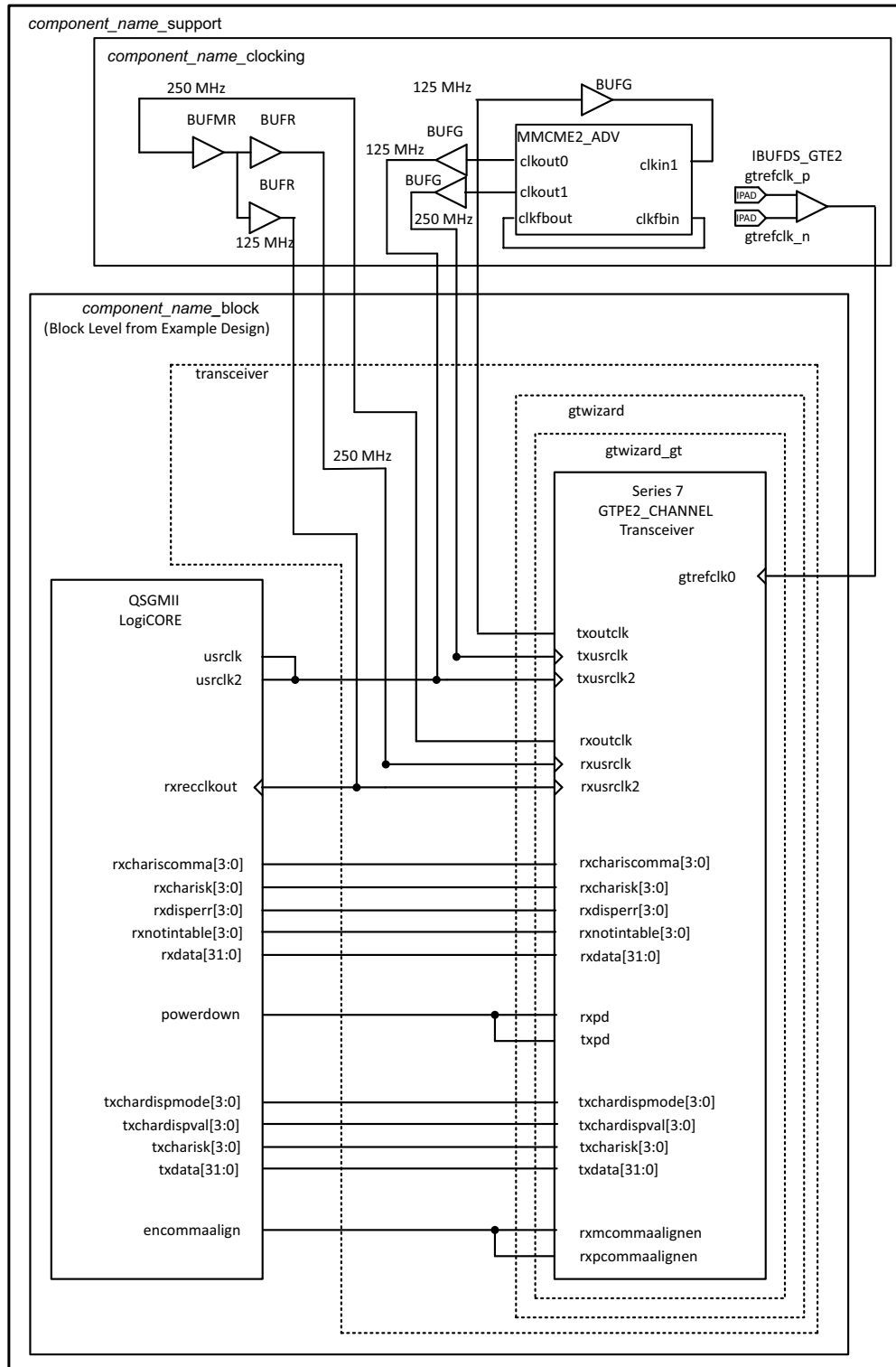


Figure 5-3: QSGMII Connection to Artix-7 FPGA Transceivers

## UltraScale and UltraScale+ Devices

The core is designed to integrate with the UltraScale device transceiver. [Figure 5-4](#) illustrates the connections and logic required between the core and the transceiver; the signal names and logic in the figure precisely match those delivered with the core hdl when an UltraScale and UltraScale+ device transceivers are used.

The 125 MHz differential reference clock is routed directly to the transceiver. The transceiver is configured to output a version of this clock (125 MHz) on the `txoutclk` port; this is then placed onto global clock routing and is input back into the transceiver on the user interface clock ports `txusrclk` and `txusrclk2`. This clock is also used to source all core logic.

The transceiver is configured to output a recovered clock (125 MHz) on the `rxoutclk` port; this is placed onto global routing through `BUFG_GT`. This clock is then used to source the receive logic from transceiver receive side output to the `rxelastic` buffer in the core. The clocking logic is included in a separate module, `<component_name>_clocking`, which is instantiated in the `<component_name>_support` module.

The transceiver subcore is auto generated and instantiated when the QSGMII core is generated.



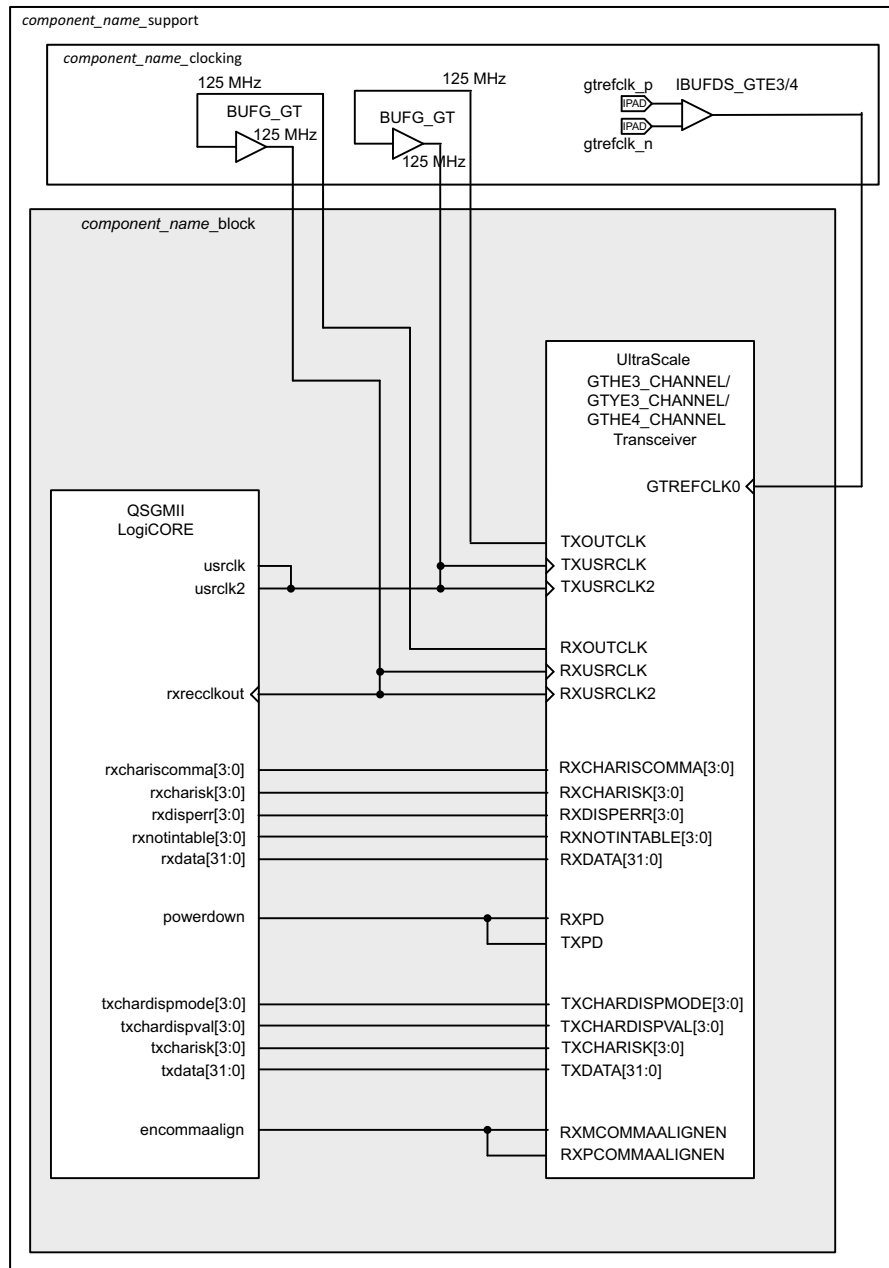


Figure 5-4: QSGMII Connection to UltraScale/UltraScale+ Device Transceivers

# Clock Sharing Across Multiple Cores with Transceivers

## Virtex-7 Devices

Figure 5-5 illustrates sharing clock resources across two instantiations of the core when using 7 series FPGA transceivers. Additional cores can be added by continuing to instantiate extra block level modules. One instance of the core is generated with the **Include Shared Logic in Core** option. This instance contains all the clocking logic that can be shared. The remaining instances can be generated using the **Include Shared Logic in Example Design** option. This method of using shared logic core is limited to a GT Quad.

To provide the FPGA logic clocks for all core instances, select a `txoutclk` port from any transceiver and place it onto global clock routing using BUFGs; it can be shared across all core instances and transceivers as illustrated.

Each transceiver and core pair instantiated has its own independent clock domains synchronous to `rxoutclk`. These are placed on BUFMR followed by regional clock routing using a BUFR, as illustrated in Figure 5-5, and cannot normally be shared across multiple transceivers. The clocking logic for `rxoutclk` can only be shared if it is known that the transceiver and core pairs across QSGMII instances are synchronous.

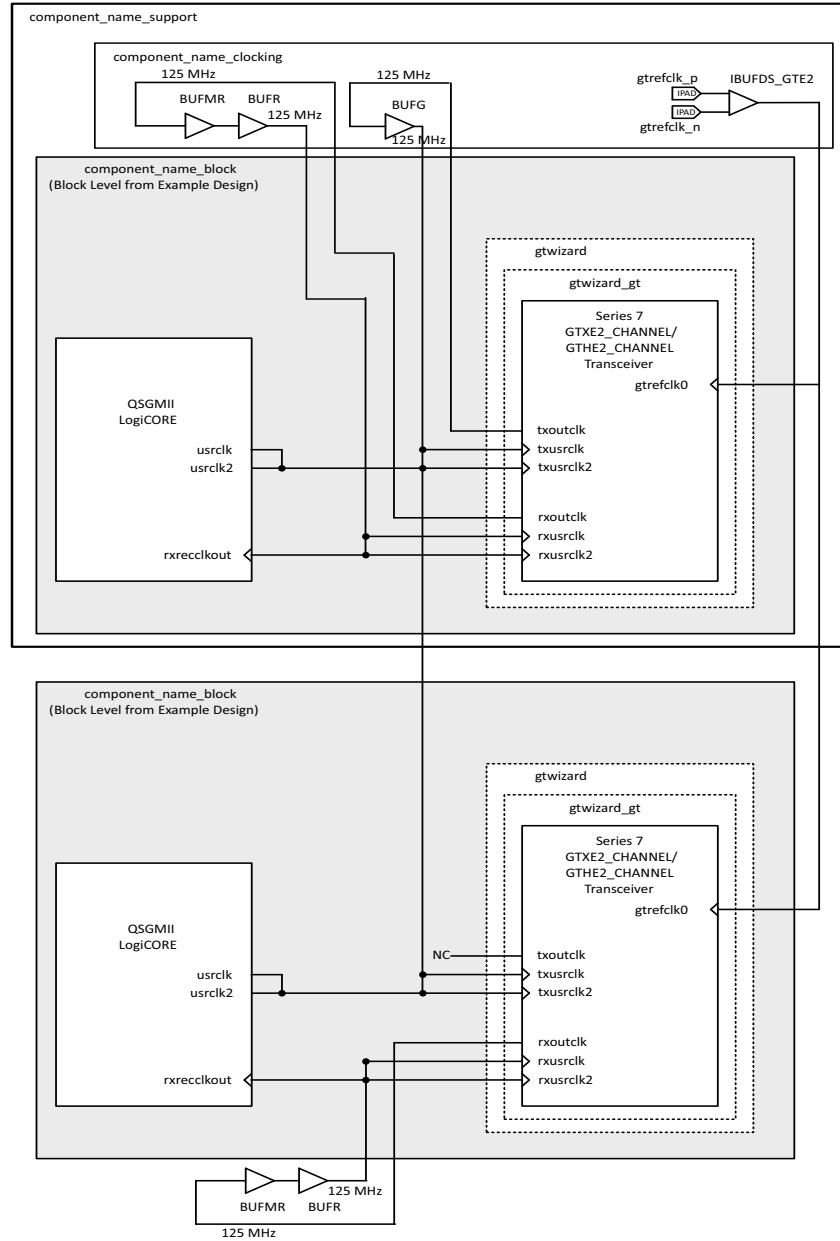


Figure 5-5: Clock Management with Multiple Core Instances with Virtex-7 FPGA Transceivers

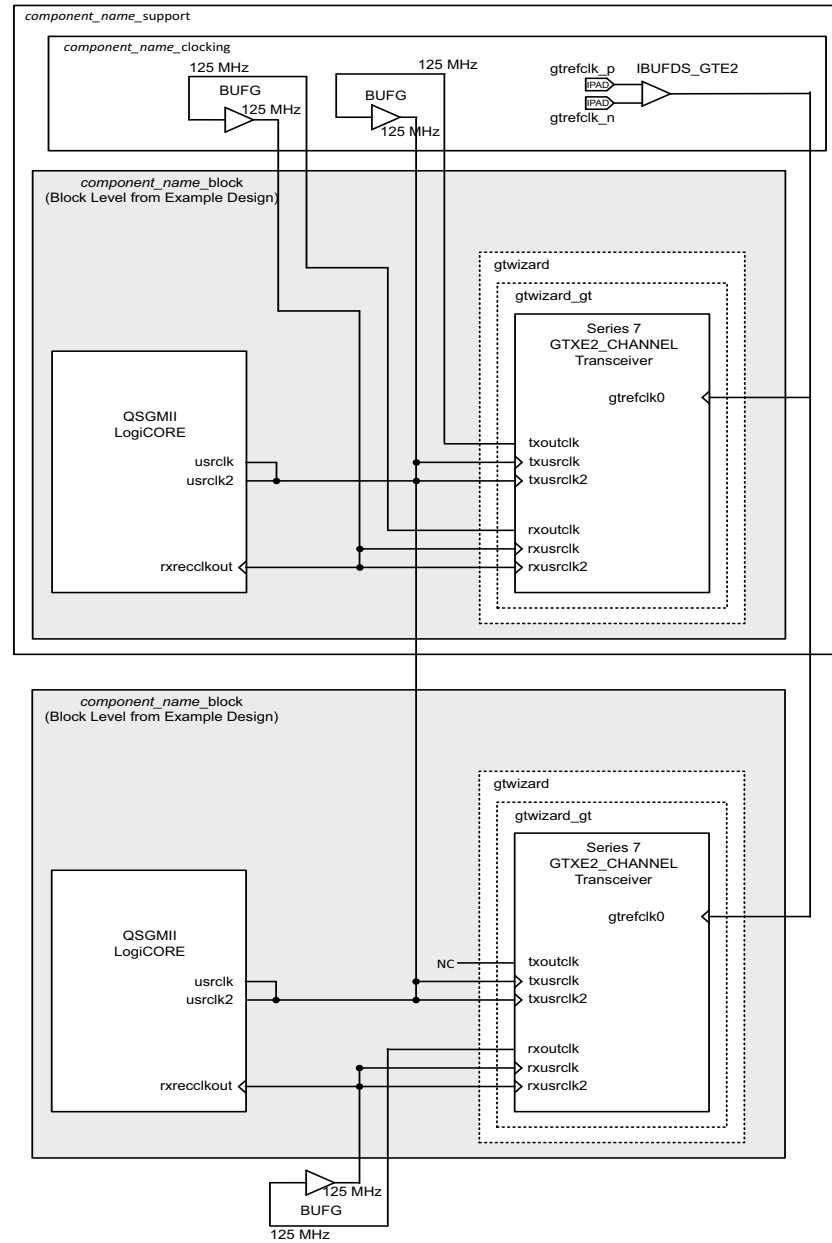
## Zynq-7000 AP SoC and Kintex-7 Devices

Figure 5-6 illustrates sharing clock resources across two instantiations of the core when using 7 series FPGAs transceivers. Additional cores can be added by continuing to instantiate extra block level modules. One instance of the core is generated with the **Include Shared Logic in Core** option. This instance contains all the clocking logic that can be shared.

The remaining instances can be generated using the **Include Shared Logic in Example Design** option. This method of using shared logic core is limited to a GT Quad.

To provide the FPGA logic clocks for all core instances, select a `txoutclk` port from any transceiver and place it onto global clock routing using BUFGs; these can be shared across all core instances and transceivers as illustrated,

Each GTX transceiver and core pair instantiated has its own independent clock domains synchronous to `rxoutclk`. These are placed on global clock routing using a BUFG, as illustrated in Figure 5-6, and cannot be normally shared across multiple transceivers. The clocking logic for `rxoutclk` can only be shared if it is known that the transceiver and core pairs across QSGMII instances are synchronous. In this case the receive clock outputs of clocking module can be used.



**Figure 5-6: Clock Management with Multiple Core Instances with Zynq-7000 AP SoC/Kintex-7 FPGA Transceivers**

## Artix-7 Devices

Figure 5-7 illustrates sharing clock resources across two instantiations of the core when using 7 series FPGAs transceivers. Additional cores can be added by continuing to instantiate extra block level modules. One instance of the core is generated with the **Include Shared Logic in Core** option. This instance contains all the clocking logic that can be shared. The remaining instances can be generated using the **Include Shared Logic in Example Design** option. The method of using the shared logic core is limited to a GT Quad.

To provide the FPGA logic clocks for all core instances, select a `txoutclk` port from any transceiver and place it onto global clock routing using BUFGs. Pass this clock to an MMCM to generate 125 and 250 MHz clocks. The 125 MHz clock is used to clock the core logic and `txusrclk2` of the transceivers. The 250 MHz clock is used to clock the `txusrclk` of the transceivers. These can be shared across all core instances and transceivers as illustrated,

Each GTP transceiver and core pair instantiated has its own independent clock domains synchronous to `rxoutclk`. These are placed on global clock routing using a BUFMR and subdivided to generate 125 MHz and 250 MHz clocks through BUFMRs respectively, as illustrated in Figure 5-7, and cannot normally be shared across multiple transceivers. The clocking logic for `rxoutclk` can only be shared if it is known that the transceiver and core pairs across QSGMII instances are synchronous. In this case the receive clock outputs of clocking module can be used. In some devices BUFMRs are not available and this scheme might not be feasible. Other schemes with a core just generated using the **Include Shared Logic in Example Design** option should be considered.

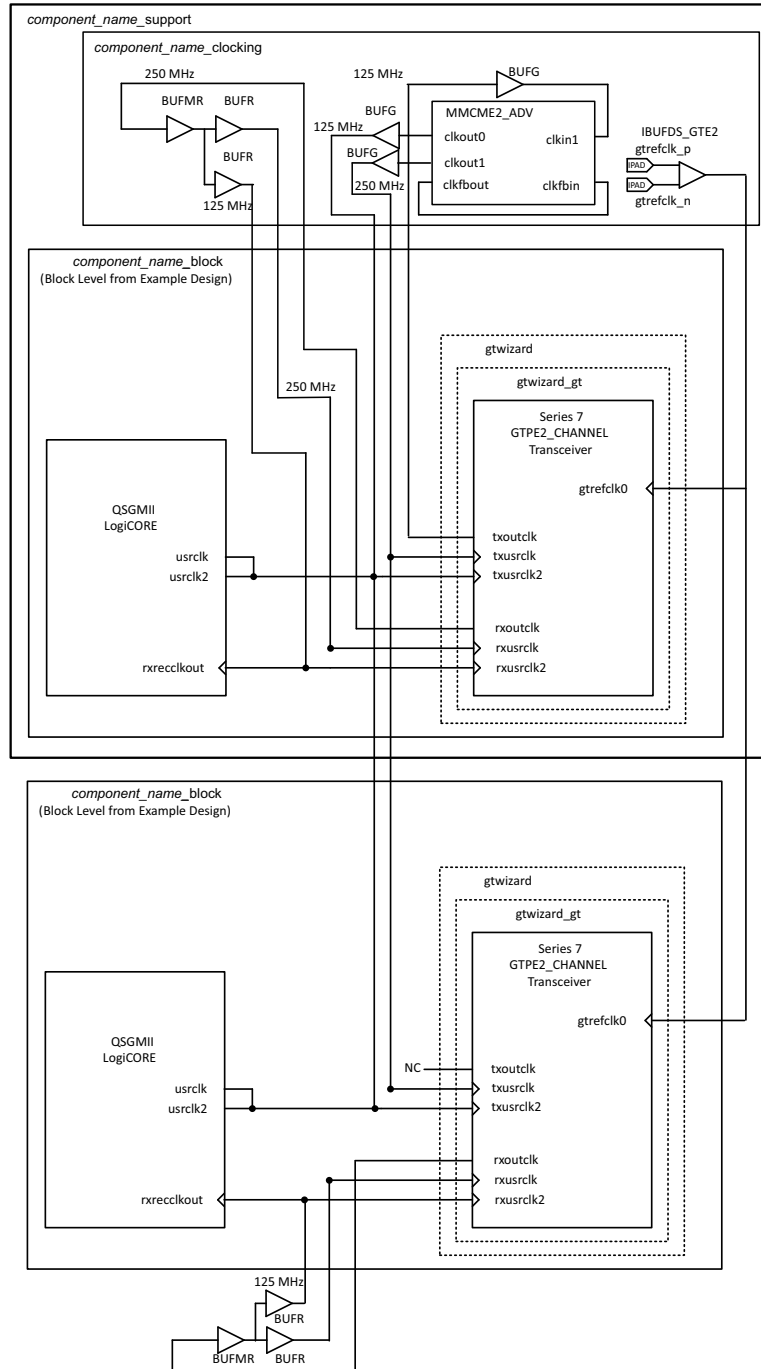


Figure 5-7: Clock Management with Multiple Core Instances with Artix-7 FPGA Transceivers

## UltraScale and UltraScale+ Devices

Figure 5-8 illustrates sharing clock resources across two instantiations of the core when using UltraScale or UltraScale+ device transceivers. Additional cores can be added by continuing to instantiate extra block level modules. One instance of the core is generated with the **Include Shared Logic in Core** option. This instance contains all the clocking logic that can be shared. The remaining instances can be generated using the **Include Shared Logic in Example Design** option. This method of using shared logic core is limited to a GT Quad.

To provide the device logic clocks for all core instances, select a `txoutclk` port from any transceiver and place it onto the global clock routing using `BUFG_GTs`; these can be shared across all core instances and transceivers as illustrated,

Each transceiver and core pair instantiated has its own independent clock domains synchronous to `rxoutclk`. These are placed on the global clock routing using a `BUFG_GT`, as illustrated in Figure 5-8, and cannot be normally shared across multiple transceivers. The clocking logic for `rxoutclk` can only be shared if it is known that the transceiver and core pairs across QSGMII instances are synchronous. In this case the receive clock outputs of clocking module can be used.



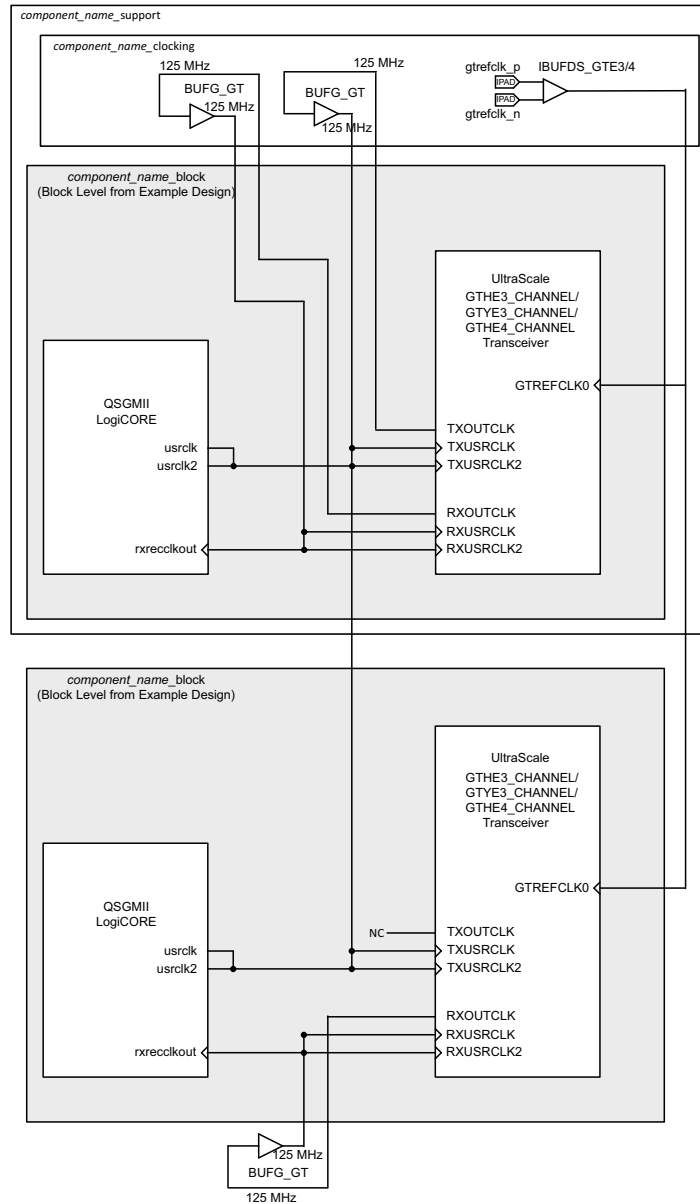


Figure 5-8: Clock Management with Multiple Core Instances with UltraScale/UltraScale+ Device Transceivers

# Design Flow Steps

This chapter describes customizing and generating the IP core, constraining the core, and the simulation, synthesis, and implementation steps specific to this core. More detailed information about the standard Vivado® design flows and the Vivado 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 8]
- *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 9]
- *Vivado Design Suite User Guide: Logic Simulation* (UG900) [Ref 10]
- *Vivado Design Suite User Guide: Getting Started* (UG910) [Ref 11]

---

## Customizing and Generating the Core

This section includes information about using Xilinx tools to customize and generate the core in the Vivado Design Suite.

If you are customizing and generating the core in the IP integrator, see the *Vivado Design Suite User Guide: Designing IP Subsystems using IP Integrator* (UG994) [Ref 8] for detailed information. IP integrator might auto-compute certain configuration values when validating or generating the design. To check whether the values do change, see the description of the parameter in this chapter. To view the parameter value, run the `validate_bd_design` command in the Tcl console.

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

1. Select the IP from the Vivado IP catalog.
2. Double-click the selected IP or select the **Customize IP** command from the toolbar or right-click menu.

For details, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 9] and the *Vivado Design Suite User Guide: Getting Started* (UG910) [Ref 11].

**Note:** Figures in this chapter are illustrations of the Vivado IDE. This layout might vary from the current version.

All parameters are available and modifiable in the IP integrator. The default configuration of the core in the IP integrator is the same as the that generated though the IP catalog.

## Core Customization Vivado IDE

Figure 6-1 displays the QSGMII customization Vivado IDE, used to set core parameters and options. For help starting and using Vivado design tools on your system, see the documentation included with the [Vivado Design Suite](#).

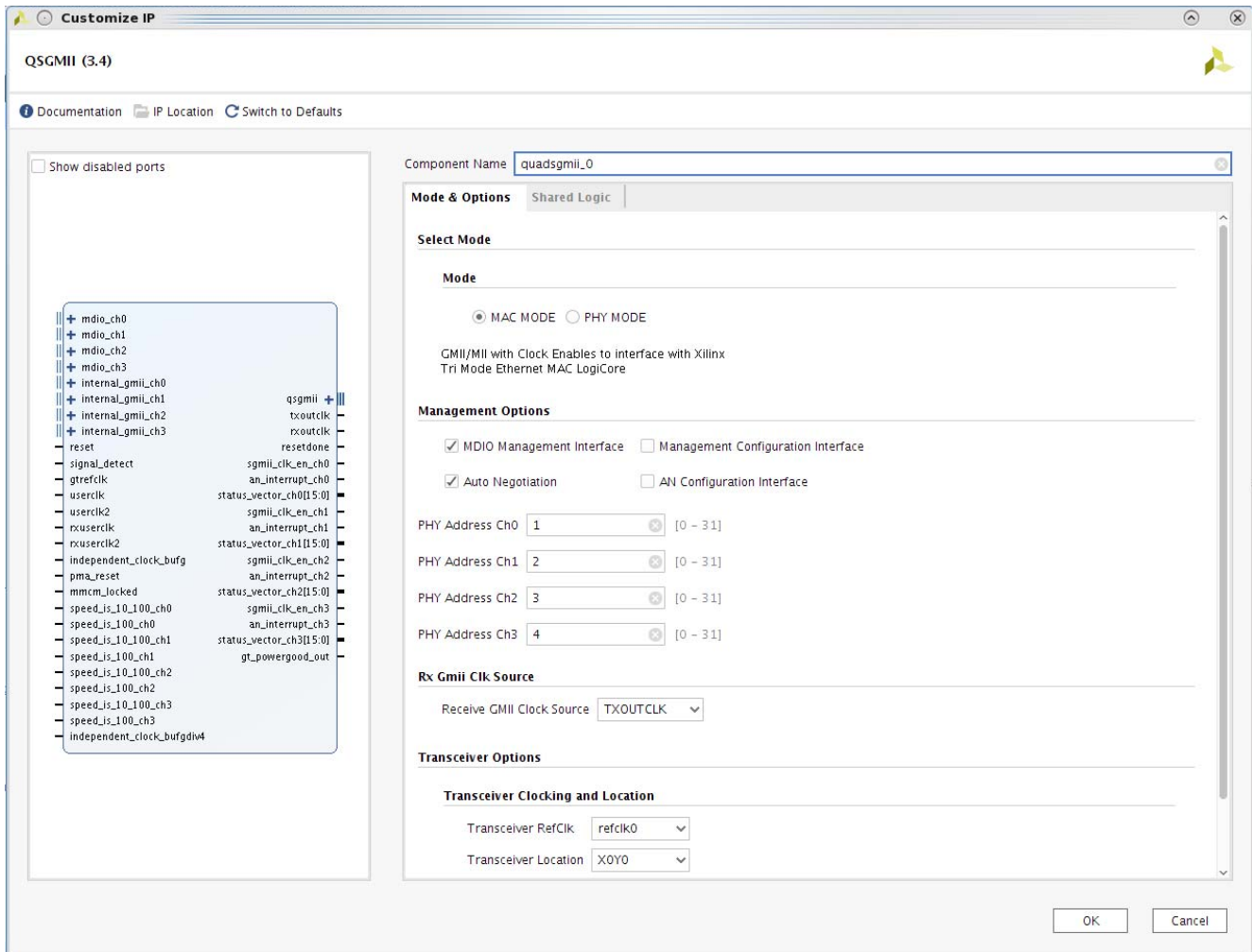


Figure 6-1: Core Customization Screen

- **Component Name** – The component name is the base name of the output files generated for the core. Names must begin with a letter and can include alphanumeric characters and the underscore (\_).
- **Select Mode** – The QSGMII core has two main modes of operation.
  - **MAC Mode** – QSGMII interfaces with the IP catalog Tri-mode Ethernet IP on the GMII client side.

- **PHY Mode** – QSGMII can interface with third-party Ethernet IP cores. The client interface can be selected as GMII or MII.
- **MDIO Management Interface** – Select this option to include the MDIO Management Interface to access the PCS Configuration registers. MDIO Management Interface is selected by default.
- **MDIO Configuration Interface** – Select this option to include an additional configuration interface to program configuration register 0 and can be used in addition to the MDIO Management Interface. This option is always selected if MDIO Management Interface is disabled.
- **Auto-Negotiation** – Select this option to include auto-negotiation functionality with the core. Auto-Negotiation is selected by default.
- **AN Configuration Interface** – Select this option to include an additional configuration interface to program the AN Advertisement register (register 4). This option is valid only if Auto-Negotiation is enabled.
- **PHY Address Chx** – Use this option to define the PHY address of the MDIO interface of individual channels in the core. The value should be in the range of 0 to 31.
- **Rx Gmii Clk Source** – This option selects the clock source of the receive path and `gmii_rx` interface. When the `RXOUTCLK` is selected, the entire receive datapath works on `rxusrclk2` and the elastic buffer on the receive path is bypassed.
- **DRP Clock Frequency** – This option is available only for UltraScale and UltraScale+™ devices and if **Additional Transceiver Control and Status Ports** is selected. This indicates the DRP frequency operation, selectable between 6.25 MHz to 125 MHz.
- **Transceiver Clocking and Location** – This option is only available when an UltraScale or UltraScale+ device is selected. This gives a list of possible sources for reference clock and location of channel for selection.
- **Additional Transceiver Control and Status Ports** – If selected, enables additional transceiver control ports for DRP, TX Driver, RX Equalization, and other features such as PRBS.

## Select Interface Vivado IDE

Figure 6-2 displays the QSGMII interface selection Vivado IDE. This Vivado IDE is only displayed if PHY Mode is selected in the Select Mode section in the initial customization screen.

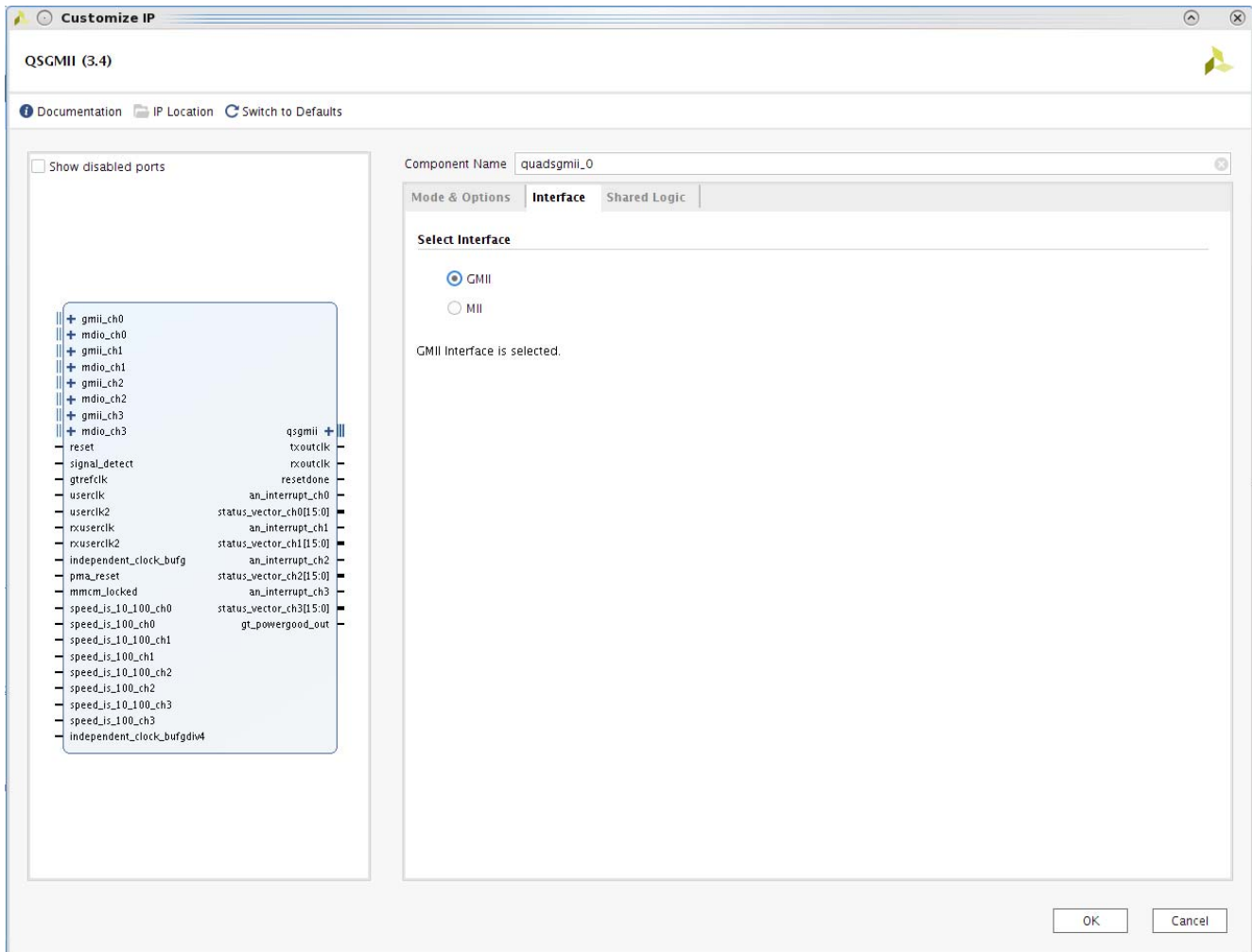


Figure 6-2: Select Interface Vivado IDE

## Shared Logic Options in Vivado IDE

Figure 6-3 displays the shared logic options as well as transceiver control and status selection in the Vivado IDE.

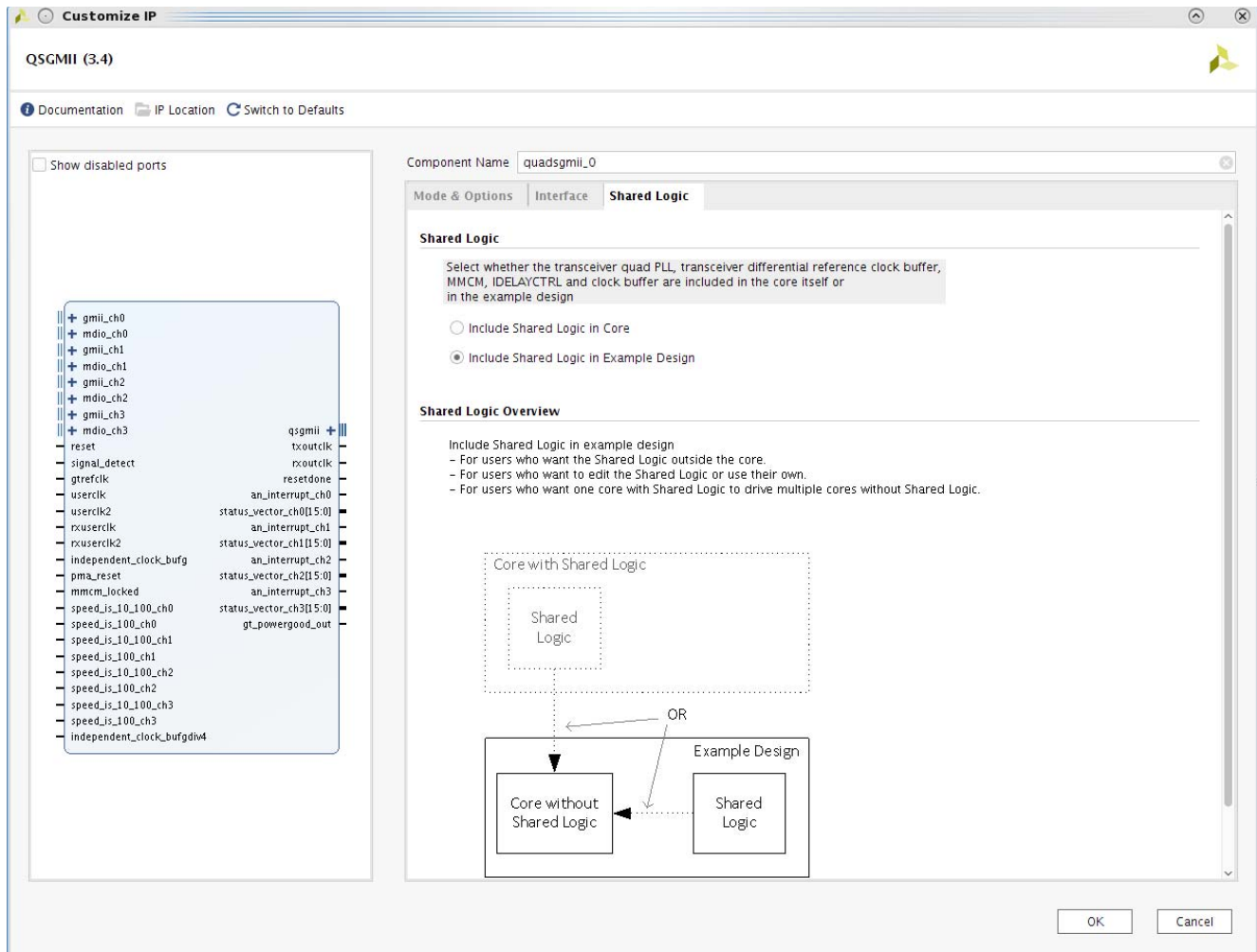


Figure 6-3: Shared Logic Options

- **Shared Logic** – Determines whether some shared clocking logic is included as part of the core or as part of the example design.

## User Parameters

Table 6-1 shows the relationship between the fields in the Vivado IDE and the User Parameters (which can be viewed in the Tcl console).

Table 6-1: Vivado IDE Parameter to User Parameter Relationship

Vivado IDE Parameter/Value <sup>(1)</sup>	User Parameter/Value <sup>(1)</sup>	Default Value
Mode	Mode	MAC_MODE
MAC MODE	MAC_MODE	
PHY MODE	PHY_MODE	
Management Options: MDIO Management Interface	Management_Interface	TRUE
Management Options: Management Configuration Interface	Config_Interface	FALSE
Management Options: Auto Negotiation	Auto_Negotiation	TRUE
Management Options: AN Configuration Interface	AN_Config_Interface	FALSE
PHY Address Ch0	C_PHYADDR_0	1
PHY Address Ch1	C_PHYADDR_1	2
PHY Address Ch2	C_PHYADDR_2	3
PHY Address Ch3	C_PHYADDR_3	4
Rx Gmii Clk Source	RxGmiiClkSrc	TXOUTCLK
Additional transceiver control and status ports	TransceiverControl	FALSE
DRP Clock Frequency	c_drpclkrate	75
Transceiver Clocking and Location: Transceiver Refclk	RefClk	refclk0
Transceiver Clocking and Location: Transceiver Locations	Locations	XOY0
Select Interface	GMII_or_MII_Mode	GMII
GMII	GMII	
MII	MII	
Shared Logic	SupportLevel	Include_Shared_Logic_in_Example_Design
Include Shared Logic in Core	Include_Shared_Logic_in_Core	
Include Shared Logic in Example Design	Include_Shared_Logic_in_Example_Design	

### 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

The QSGMII solution delivers files into several filegroups. By default the filegroups necessary for use of the QSGMII or opening the IP example design are generated when the core is generated. If additional filegroups are required these can be selected using the generate option.

For details, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 9].

The filegroups generated can be seen in the IP Sources tab of the Sources window where they are listed for each IP in the project. The filegroups available for the QSGMII solution are:

### **Examples**

Includes all source required to be able to open and implement the IP example design project, that is, example design HDL and the example design XDC file.

### **Examples Simulation**

Includes all source required to be able to simulate the IP example design project. This is the same list of HDL as the Examples filegroup with the addition of the demonstration test bench HDL.

### **Synthesis**

Includes all synthesis sources required by the core. For the QSGMII solution this is a mix of both encrypted and unencrypted source. Only the unencrypted sources are visible.

### **Simulation**

Includes all simulation sources required by the core. Simulation of the QSGMII solution at the core level is not supported without the addition of a test bench (not supplied). Simulation of the example design is supported.

### **Instantiation Template**

Example instantiation template.

### **Miscellaneous**

This provides simulations scripts and support files required for running netlist based functional simulation. The files delivered as part of this filegroup are not used or understood by Vivado design tools and as such this filegroup is not displayed. These files are delivered into the project source directory.



## Constraining the Core

This section contains information about constraining the core in the Vivado Design Suite and defines the constraint requirements of the QSGMII core. An example XDC file is also provided with the HDL example design to provide the board level constraints. This is specific to the example design and, as such, is only expected to be used as a template for the user design. See [Chapter 7, Example Design](#). This XDC file, named `<component name>_example_design.xdc`, is found in the IP Sources tab of the Sources window in the Examples file group.

## Device, Package, and Speed Grade Selections

The QSGMII core can be implemented in UltraScale+ families, UltraScale architecture, Zynq<sup>®</sup>-7000 All Programmable SoC, Virtex<sup>®</sup>-7, Kintex<sup>®</sup>-7, and Artix<sup>®</sup>-7 devices. When selecting a device, be aware of the following considerations:

- Device must be large enough to accommodate the core
- Device must contain a sufficient number of IOBs
- -1 speed grade for Z-7030, Z-7045, and Z-7100 Zynq parts and all Virtex-7 and Kintex-7 devices
- -2 speed grade and faster for Z-7105 Zynq part and all Artix-7 devices

## I/O Location Constraints

No specific I/O location constraints are required.

However, when employing BUFIO and BUFR regional clock routing, ensure that a BUFIO capable clock input pin is selected for input clock sources, and that all related input synchronous data signals are placed in the respective BUFIO region. The user guide for the appropriate family should be consulted.

## Placement Constraints

No specific placement constraints are required.

## Transceiver Placement

### *Virtex-7 FPGA GTH Transceivers*

The constraints defined in this section are implemented in the XDC for the example designs delivered with the core. Sections from the XDC are copied into the following descriptions to serve as examples and should be studied with the HDL source code for the example design.

For more information, see the *7 Series FPGAs GTX/GTH Transceivers User Guide (UG476)* [Ref 6].

### Transceiver Placement Constraint

The provided XDC uses placement constraints to specify the serial transceiver that is used when the core is implemented. This can be moved around according to the application.

```
set_property LOC GTHE2_CHANNEL_X0Y4 [get_cells */***/transceiver_inst/
gtwizard_inst/*/GTWIZARD_i/gt0_GTWIZARD_i/gthe2_i
```

### Clock Period Constraints

The `gtrefclk` clock is provided to the GTH transceiver. It is a high-quality reference clock with a frequency of 125 MHz and should be constrained.

```
#####
# PCS/PMA Clock period Constraints: please do not relax *
#####
create_clock -add -name gtrefclk -period 8.000 [get_ports gtrefclk_p]
```

### GTH Transceiver Attributes

The Virtex-7 FPGA GTH transceiver has many attributes that are set directly from the HDL source code for the transceiver wrapper file delivered with the example design. These can be found in the `gtwizard_gt.vhd` file (for VHDL design entry) or the `gtwizard_gt.v` file (for Verilog design entry); these files were generated using the 7 series FPGA transceiver wizard. To change the attributes, re-run the wizard.

### Virtex-7 FPGA GTX Transceivers

The constraints defined in this section are implemented in the XDC for the example designs delivered with the core. Sections from the XDC are copied into the following descriptions to serve as examples and should be studied with the HDL source code for the example design. For more information, see the *7 Series FPGAs GTX/GTH Transceivers User Guide (UG476)* [Ref 6].

### Transceiver Placement Constraint

The provided XDC uses placement constraints to specify the serial transceiver that is used when the core is implemented. This can be moved around according to the application.

```
set_property LOC GTXE2_CHANNEL_X0Y1 [get_cells get_cells */***/transceiver_inst/
gtwizard_inst/*/GTWIZARD_i/gt0_GTWIZARD_i/gtxe2_i
```

### Clock Period Constraints

The `gtrefclk` clock is provided to the GTX transceiver. It is a high-quality reference clock with a frequency of 125 MHz and should be constrained.

```

#*****
# PCS/PMA Clock period Constraints: please do not relax    *
#*****

create_clock -add -name gtreclk -period 8.000 [get_ports gtreclk_p]
    
```

### GTX Transceiver Attributes

The Virtex-7 FPGA GTX transceiver has many attributes that are set directly from the HDL source code for the transceiver wrapper file delivered with the example design. These can be found in the `gtwizard_gt.vhd` file (for VHDL design entry) or the `gtwizard_gt.v` file (for Verilog design entry); these files were generated using the 7 series FPGA transceiver wizard. To change the attributes, re-run the wizard.

### Zynq-7000 AP SoC and Kintex-7 FPGA GTX Transceivers

The constraints defined in this section are implemented in the XDC for the example designs delivered with the core. Sections from the XDC are copied into the following descriptions to serve as examples, and should be studied with the HDL source code for the example design. For more information, see the *7 Series FPGAs GTX/GTH Transceivers User Guide* (UG476) [Ref 6].

### Transceiver Placement Constraint

The provided XDC uses placement constraints to specify the serial transceiver that is used when the core is implemented. This can be moved around according to the application.

```

set_property LOC GTXE2_CHANNEL_X0Y10 [get_cells get_cells */**/transceiver_inst/
gtwizard_inst/*/GTWIZARD_i/gt0_GTWIZARD_i/gtxe2_i
    
```

### Clock Period Constraints

The `gtreclk` clock is provided to the GTX transceiver. It is a high-quality reference clock with a frequency of 125 MHz and should be constrained.

```

#*****
# PCS/PMA Clock period Constraints: please do not relax    *
#*****

create_clock -add -name gtreclk -period 8.000 [get_ports gtreclk_p]
    
```

### GTX Transceiver Attributes

The Zynq-7000/Kintex-7 FPGA GTX transceiver has many attributes that are set directly from the HDL source code for the transceiver wrapper file delivered with the example design. These can be found in the `gtwizard_gt.vhd` file (for VHDL design entry) or the `gtwizard_gt.vhd.v` file (for Verilog design entry); these files were generated using the 7 series FPGA transceiver wizard. To change the attributes, re-run the wizard.

## Artix-7 FPGA GTP Transceivers

The constraints defined in this section are implemented in the XDC for the example designs delivered with the core. Sections from the XDC are copied into the following descriptions to serve as examples, and should be studied with the HDL source code for the example design. For more information, see the *7 Series FPGAs GTP Transceivers User Guide* (UG482) [Ref 7].

### Transceiver Placement Constraint

The provided XDC uses placement constraints to specify the serial transceiver that is used when the core is implemented. This can be moved around according to the application.

```
set_property LOC GTPE2_CHANNEL_X0Y4
[get_cells get_cells */***/transceiver_inst/gtwizard_inst/*/GTWIZARD_i/
gt0_GTWIZARD_i/gtpe2_i
```

### Clock Period Constraints

The `gtrefclk` clock is provided to the GTP transceiver. It is a high-quality reference clock with a frequency of 125 MHz and should be constrained.

```
#*****
# PCS/PMA Clock period Constraints: please do not relax *
#*****
create_clock -add -name gtrefclk -period 8.000 [get_ports gtrefclk_p]
```

### GTP Transceiver Attributes

The Artix-7 FPGA GTP transceiver has many attributes that are set directly from the HDL source code for the transceiver wrapper file delivered with the example design. These can be found in the `gtwizard_gt.vhd` file (for VHDL design entry) or the `gtwizard_gt.vhd.v` file (for Verilog design entry); these files were generated using the 7 series FPGA transceiver wizard. To change the attributes, re-run the wizard.

## Constraints When Using External GMII/MII

The constraints defined in this section are used when the core is operated in **PHY\_MODE**.

### Clock Period Constraints

The core has four instances of SGMII cores. These constraints are valid only when the core is generated with the `MODE` parameter set to **PHY\_MODE** and the `Interface` parameter set to **GMII** in the Vivado IDE. When implementing an external GMII, the Transmitter Elastic Buffer embedded in the QSGMII block is used. The input transmitter GMII signals are then synchronous to their own clock domain (`gtx_clk_chx` is used in the example design). These clocks must be constrained for a clock frequency of 125 MHz. The following XDC syntax shows the necessary constraints being applied to the example design.

```

#*****
# GMII GTX transceiver CLK for clocking in GMII TX Interface*
#*****

create_clock -add -name gtx_clk_ch0 -period 8.000 [get_ports gtx_clk_ch0]

create_clock -add -name gtx_clk_ch1 -period 8.000 [get_ports gtx_clk_ch1]

create_clock -add -name gtx_clk_ch2 -period 8.000 [get_ports gtx_clk_ch2]

create_clock -add -name gtx_clk_ch3 -period 8.000 [get_ports gtx_clk_ch3]

```

### GMII/MII IOB Constraints

The following constraints target the flip-flops that are inferred in the top-level HDL file for the example design. These constraints are defined for receive signals; the transmit GMII/MII interface passes through IDELAY modules to adjust for latency. See [GMII Input Setup/Hold Timing](#). Constraints are set to ensure that these are placed in IOBs.

```

#*****
# GMII Receiver Constraints: place flip-flops in IOB      *
#*****

set_property IOB TRUE [get_cells gmii_rxd_ch0_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_dv_ch0_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_er_ch0_obuf_reg*]

set_property IOB TRUE [get_cells gmii_rxd_ch1_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_dv_ch1_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_er_ch1_obuf_reg*]

set_property IOB TRUE [get_cells gmii_rxd_ch2_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_dv_ch2_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_er_ch2_obuf_reg*]

set_property IOB TRUE [get_cells gmii_rxd_ch3_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_dv_ch3_obuf_reg*]
set_property IOB TRUE [get_cells gmii_rx_er_ch3_obuf_reg*]

```

Virtex-7 devices support GMII at 3.3V or lower only in certain parts and packages. See the Virtex-7 device documentation. GMII/MII by default is supported at 3.3V and the XDC contains the following syntax. Use this syntax together with the device I/O Banking rules.

```

#*****
# GMII IOSTANDARD Constraints: please select an I/O      *
# Standard (LVTTTL is suggested).                       *
#*****

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch0[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch0]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch0]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch0[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch0]

```

```

set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch0]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch1[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch1]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch1]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch1[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch1]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch1]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch2[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch2]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch2]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch2[*]}]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch0[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch0]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch0]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch1[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch1]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch1]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch1[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch1]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch1]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch2[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch2]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch2]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch2[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch2]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch2]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_txd_ch3[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_en_ch3]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_tx_er_ch3]

set_property IOSTANDARD LVCMOS33 [get_ports {gmii_rxd_ch3[*]}]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_dv_ch3]
set_property IOSTANDARD LVCMOS33 [get_ports gmii_rx_er_ch3]

set_property IOSTANDARD LVCMOS33 [get_ports gtx_clk_ch0]
set_property IOSTANDARD LVCMOS33 [get_ports gtx_clk_ch1]
set_property IOSTANDARD LVCMOS33 [get_ports gtx_clk_ch2]
set_property IOSTANDARD LVCMOS33 [get_ports gtx_clk_ch3]

```

### ***GMII Input Setup/Hold Timing***

Figure 6-4 and Table 6-2 illustrate the setup and hold time window for the input GMII signals. These are the worst-case data valid window presented to the FPGA pins.

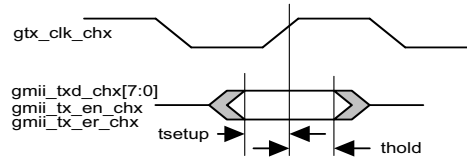


Figure 6-4: Input GMII Timing Specification

Observe that there is, in total, a 2 ns data valid window of guaranteed data that is presented across the GMII input bus. This must be correctly sampled by the FPGA devices.

Table 6-2: Input GMII Timings

Symbol	Min	Max	Units
$t_{\text{SETUP}}$	2.00	-	ns
$t_{\text{HOLD}}$	0.00	-	ns

## Zynq-7000 AP SoC, Virtex-7, Kintex-7, and Artix-7 Devices

Figure C-1 in Appendix C illustrates the GMII input logic provided in the core for the Zynq-7000 AP SoC, Virtex-7, Kintex-7, and Artix-7 family.

Figure C-2 in Appendix C illustrates the MII input logic provided in the core for the Zynq-7000 AP SoC, Virtex-7, Kintex-7, and Artix-7 family.

IDELAY elements are instantiated on the GMII/MII data input path as illustrated. Fixed tap delays are applied to these IDELAY elements to delay the GMII/MII input data signals so that data is correctly sampled at the IOB IDDR registers, thereby meeting GMII/MII input setup and hold timing constraints.

The number of tap delays are applied using the following XDC syntax.

```

*****
# To Adjust GMII Tx Input Setup/Hold Timing *
*****
# These constraints will be set at a later date when device speed files have matured
set_property IDELAY_VALUE 0 [get_cells delay_gmii_tx_en_ch0]
set_property IDELAY_VALUE 0 [get_cells delay_gmii_tx_er_ch0]

set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[7].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[6].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[5].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[4].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[3].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[2].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[1].delay_gmii_txd_ch0}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch0[0].delay_gmii_txd_ch0}]

set_property IDELAY_VALUE 0 [get_cells delay_gmii_tx_en_ch1]
set_property IDELAY_VALUE 0 [get_cells delay_gmii_tx_er_ch1]

```

```

set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[7].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[6].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[5].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[4].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[3].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[2].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[1].delay_gmii_txd_ch1}]
set_property IDELAY_VALUE 0 [get_cells {gmii_data_bus_ch1[0].delay_gmii_txd_ch1}]

```

The number of tap delays are preconfigured in the example designs to meet the setup and hold constraints for the example GMII/MII pinout in the particular device.

---

## Simulation

For comprehensive information about Vivado simulation components and information about using supported third-party tools, see the *Vivado Design Suite User Guide: Logic Simulation* (UG900) [Ref 10].

All required simulation sources are included for the core. Simulation of the QSGMII core at the core level is not supported without the addition of a test bench (not supplied). Simulation of the example design is supported.



**IMPORTANT:** For cores targeting 7 series or Zynq-7000 AP SoC devices, UNIFAST libraries are not supported. Xilinx IP is tested and qualified with UNISIM libraries only.

---



---

## Synthesis and Implementation

For details about synthesis and implementation, see the *Vivado Design Suite User Guide: Designing with IP* (UG896) [Ref 9].

All required synthesis sources are included for the core. For the QSGMII core 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.



# Example Design

This chapter provides detailed information about the deliverables provided by the Vivado® Design Suite for the QSGMII core.

Figure 7-1 illustrates an example design for top-level HDL for the QSGMII using a device-specific transceiver (UltraScale+™ families, UltraScale™ architecture, Zynq®-7000 All Programmable SoC, Virtex®-7, Kintex®-7, or Artix®-7 devices).

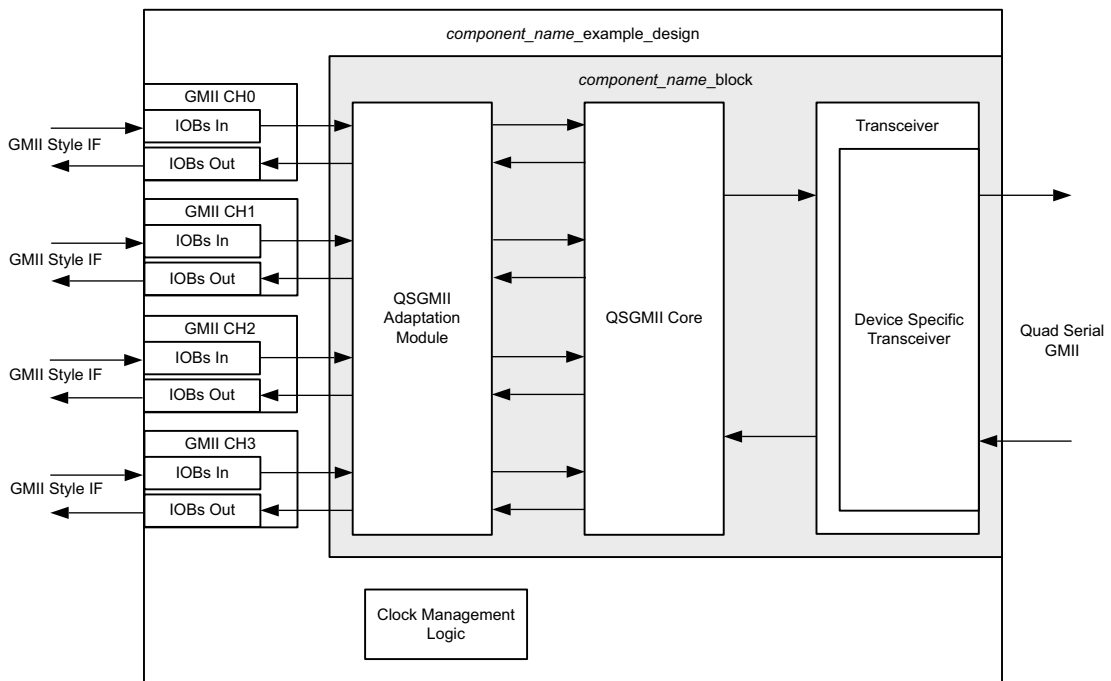


Figure 7-1: Example Design HDL for QSGMII

As illustrated, the example is split between two hierarchical layers. The block level is designed so that it can be instantiated directly into customer designs and performs the following functions:

- Instantiates the core from HDL
- Connects the physical-side interface of the core to a device-specific transceiver
- Implements an external GMII-style interface

- Connects the client side GMII of the core to an QSGMII Adaptation Module, which provides the functionality to operate at speeds of 1 Gb/s, 100 Mb/s and 10 Mb/s

The top-level of the example design creates a specific example which can be simulated, synthesized and implemented. The top-level of the example design performs the following functions:

- Instantiates the block level from HDL in case shared logic in the core is selected, otherwise support level.
- Derives the clock management logic for device-specific transceiver and the core.

The next few pages in this section describe each of the example design blocks (and associated HDL files) in detail. The example design can be opened in a separate project by generating the **Examples** output product, right-click the core instance, and select **Open IP Example Design...**

---

## Top-Level Example Design HDL

The top-level example design for the QSGMII core is described in the following files:

VHDL

```
/example_design/<component_name>_example_design.vhd
```

Verilog

```
/example_design/<component_name>_example_design.v
```

The example design HDL top-level contains the following:

- An instance of the QSGMII block level in case shared logic in the core is selected, otherwise support level.
- Clock management logic for the core and the device-specific transceiver, including DCM (if required) and Global Clock Buffer instances.

The example design HDL top-level connects the GMII interfaces of the block level to external IOBs. This allows the functionality of the core to be demonstrated using a simulation package, as described in this guide.

## Support Level HDL

The following files describe the block level for the QSGMII core. The files can be found in the `/synth` directory if shared logic in the core is selected or `/example_design` if shared logic in the example design is selected while generating the core.

### VHDL

```
/synth/<component_name>_support.vhd or  
/example_design/support/<component_name>_support.vhd
```

### Verilog

```
/synth/<component_name>_support.vhd or  
/example_design/support/<component_name>_support.vhd
```

`<component_name>_support` module instantiates `idelayctrl`, clocking, and reset modules.

### VHDL

```
/synth/<component_name>_idelayctrl.vhd or  
/example_design/support/<component_name>_idelayctrl.vhd
```

```
/synth/<component_name>_clocking.vhd or  
/example_design/support/<component_name>_clocking.vhd
```

```
/synth/<component_name>_resets.vhd or  
/example_design/support/<component_name>_resets.vhd
```

### Verilog

```
/synth/<component_name>_idelayctrl.v or  
/example_design/support/<component_name>_idelayctrl.v
```

```
/synth/<component_name>_clocking.v or  
/example_design/support/<component_name>_clocking.v
```

```
/synth/<component_name>_resets.v or  
/example_design/support/<component_name>_resets.v
```

## Block Level HDL

The following files describe the block level for the QSGMII core:

VHDL

```
/synth/<component_name>_block.vhd
```

Verilog

```
/synth/<component_name>_block.v
```

The block level contains the following:

- An instance of the QSGMII core
- An instance of a transceiver specific to the target device
- External GMII logic, including IOB and double data rate (DDR) register instances, where required
- An QSGMII adaptation module containing four instances of SGMII adaptation module. Each instance of SGMII adaptation module contains
  - The clock management logic required to enable the instance of SGMII operate at 10 Mb/s, 100 Mb/s, and 1 Gb/s.
  - GMII logic for both transmitter and receiver paths.
    - In MAC mode, the GMII style 8-bit interface is run at 125 MHz for 1 Gb/s operation; 12.5 MHz for 100 Mb/s operation; 1.25 MHz for 10 Mb/s operation.
    - In PHY mode, the GMII style 8 bit interface is run at 125 MHz for 1 Gb/s operation; 25 MHz for 100 Mb/s operation; 2.5 MHz for 10 Mb/s operation. For 100/10 Mb/s operation, 4 bits of the MII are mapped to the LSB 4 bits of the GMII style interface.

The block-level HDL connects the PHY side interface of the core to a device-specific transceiver instance and the client side to QSGMII adaptation logic as illustrated in [Figure 7-1](#). This is the most useful part of the example design and should be instantiated in all customer designs that use the core.

# Transceiver Files for Zynq-7000 AP SoC, Virtex-7, Kintex-7, or Artix-7 Devices

## Transceiver Wrapper

This device-specific transceiver wrapper is instantiated from the block-level HDL file of the example design and is described in the following files:

VHDL

```
/synth/transceiver/<component_name>_transceiver.vhd
```

Verilog

```
/synth/transceiver/<component_name>_transceiver.v
```

This file instances output source files from the transceiver wizard (used with QSGMII attributes).

## Zynq-7000 AP SoC, Virtex-7, Kintex-7, and Artix-7 Device Transceiver Wizard Files

The transceiver wrapper file directly instantiates device-specific transceiver wrapper files created from the transceiver wizard. These files tie off (or leave unconnected) unused I/O for the transceiver, and apply the QSGMII attributes. The files can be edited/tailored by rerunning the wizard and swapping these files. The files delivered might include some or all of the following:

VHDL

```
/synth/transceiver/<component_name>_gtwizard_init.vhd
/synth/transceiver/<component_name>_gtwizard_tx_startup_fsm.vhd
/synth/transceiver/<component_name>_gtwizard_rx_startup_fsm.vhd
/synth/transceiver/<component_name>_gtwizard_gtp_gtrxreset_seq.vhd
/synth/transceiver/<component_name>_gtwizard_gtp_rxpmarst_seq_vhd.vhd
/synth/transceiver/<component_name>_gtwizard_gtp_rxrate_seq.vhd
/synth/transceiver/<component_name>_gtwizard.vhd
/synth/transceiver/<component_name>_gtwizard_gt.vhd
/synth/transceiver/<component_name>_gtwizard_multi_gt.vhd
```

Verilog

```
/synth/transceiver/<component_name>_gtwizard_init.v
/synth/transceiver/<component_name>_gtwizard_tx_startup_fsm.v
/synth/transceiver/<component_name>_gtwizard_rx_startup_fsm.v
/synth/transceiver/<component_name>_gtwizard_gtp_gtrxreset_seq.v
/synth/transceiver/<component_name>_gtwizard_gtp_rxpmarst_seq_vhd.v
/synth/transceiver/<component_name>_gtwizard_gtp_rxrate_seq.v
/synth/transceiver/<component_name>_gtwizard.v
```

```
/synth/transceiver/<component_name>_gtwizard_gt.v
/synth/transceiver/component_name>_gtwizard_multi_gt.v
```

## QSGMII Adaptation Module

An QSGMII adaptation module containing four instances of SGMII adaptation module. Each instance of SGMII adaptation module contains the following:

- The clock management logic required to enable the instance of SGMII operate at 10 Mb/s, 100 Mb/s, and 1 Gb/s.
- GMII logic for both transmitter and receiver paths.
  - In MAC mode the GMII style 8-bit interface is run at 125 MHz for 1 Gb/s operation; 12.5 MHz for 100 Mb/s operation; 1.25 MHz for 10 Mb/s operation. The speed of operation is controlled by clock enables. The reference clock out (sgmii\_clk\_chx) is always 125 MHz.
  - In PHY mode the GMII style 8-bit interface is run at 125 MHz for 1 Gb/s operation; 25 MHz for 100 Mb/s operation; 2.5 MHz for 10 Mb/s operation. For 100/10 Mb/s operation, LSB 4 bits of the GMII style interface is mapped to four bits of the MII.

The QSGMII Adaptation Module is described in the following files:

### VHDL

```
<project_dir>/<component_name>/synth/qsgmii_adapt/
  <component_name>_qsgmii_adapt.vhd
  <component_name>_sgmii_adapt.vhd
  <component_name>_clk_gen.vhd
  <component_name>_clk_div.vhd
  <component_name>_johnson_cntr.vhd
  <component_name>_tx_rate_adapt.vhd
  <component_name>_rx_rate_adapt.vhd
```

### Verilog

```
<project_dir>/<component_name>/synth/qsgmii_adapt/
  <component_name>_qsgmii_adapt.v
  <component_name>_sgmii_adapt.v
  <component_name>_clk_gen.v
  <component_name>_clk_div.v
  <component_name>_johnson_cntr.v
  <component_name>_tx_rate_adapt.v
  <component_name>_rx_rate_adapt.v
```

The GMII of the core always operates at 125 MHz. The core makes no differentiation between the three speeds of operation; it always effectively operates at 1 Gb/s. However, at 100 Mb/s, every data byte run through the core should be repeated 10 times to achieve the required bit rate; at 10 Mb/s, each data byte run through the core should be repeated 100 times to achieve the required bit rate. Dealing with this repetition of bytes is the function of the SGMII adaptation module and its component blocks.

# Test Bench

This chapter contains information about the test bench provided in the Vivado® Design Suite.

Figure 8-1 illustrates the demonstration test bench for the QSGMII core. The demonstration test bench is a simple VHDL or Verilog program to exercise the example design and the core itself.

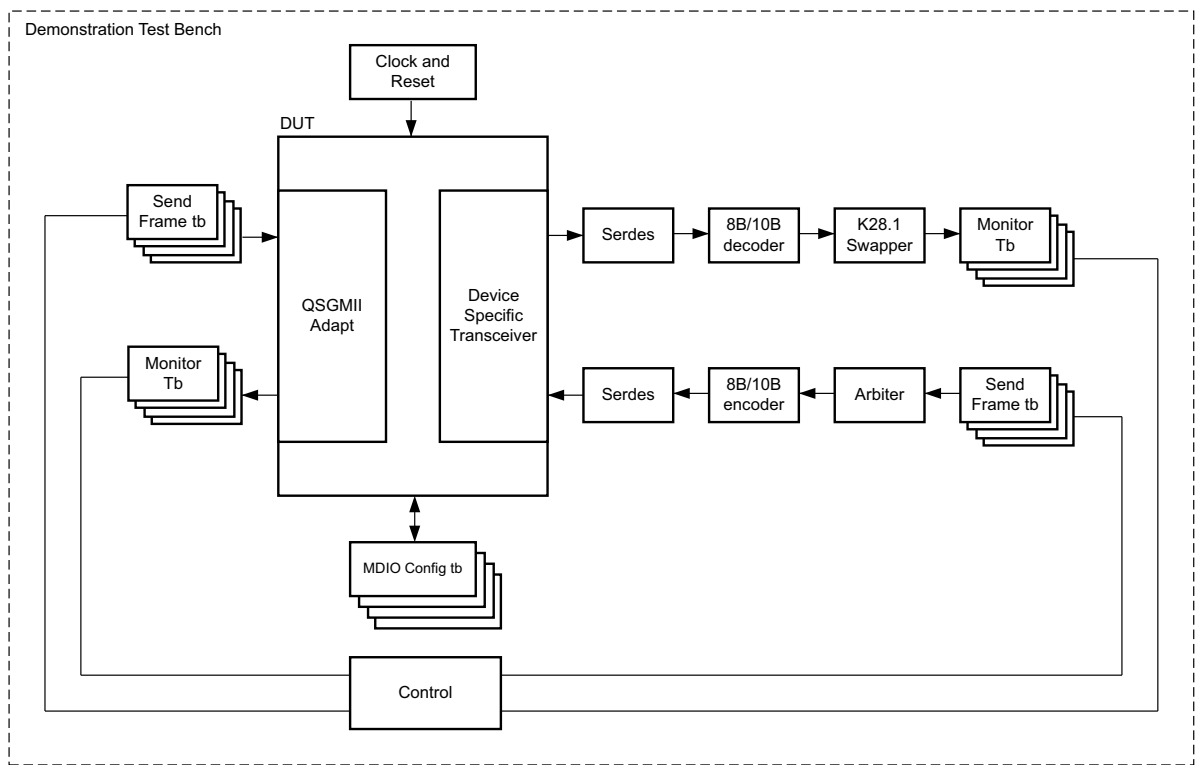


Figure 8-1: Demonstration Test Bench for QSGMII

The top-level test bench entity instantiates the example design for the core, which is the device under test (DUT). Other modules needed to provide stimulus, clocks, resets, and test bench semaphores are also instantiated in the top-level test bench. The following files describe the top-level of the demonstration test bench.



## VHDL

```
/simulation/demo_tb.vhd
```

## Verilog

```
/simulation/demo_tb.v
```

Send frame test bench generates the stimulus to excite the transceiver on the DUT receive side and data input on the DUT QSGMII adapt side. Four instances of the send frame test bench are instantiated, with each instance representing one channel.

## VHDL

```
/simulation/send_frame_tb.vhd
```

## Verilog

```
/simulation/send_frame_tb.v
```

The Arbiter module selects one byte from each instance of the send frame test bench and passes it on to the 8B/10B encoder module.

## VHDL

```
/simulation/arbiter_tb.vhd
```

## Verilog

```
/simulation/arbiter_tb.v
```

The 8B/10B encoder test bench module converts 8-bit data from arbiter to 10 bits as specified by *IEEE 802.3-2008 Specification* [Ref 2] standard clause 36.

## VHDL

```
/simulation/encode_8b10b_tb.vhd
```

## Verilog

```
/simulation/encode_8b10b_tb.v
```

The 8B/10B decoder test bench module converts 10-bit data from SerDes on the transceiver transmit interface to 8 bits as specified by *IEEE 802.3-2008 Specification* [Ref 2] standard clause 36.

## VHDL

```
/simulation/decode_8b10b_tb.vhd
```

## Verilog

```
/simulation/decode_8b10b_tb.v
```

The SerDes module serializes the 10-bit data from the 8B/10B encoder and maps it to the receive interface of the DUT transceiver. This module de-serializes the serial bitstream from the transmit interface of the DUT transceiver and maps it to the 8B/10B decoder.

#### VHDL

```
/simulation/serdes_tb.vhd
```

#### Verilog

```
/simulation/serdes_tb.v
```

The K28.1 swapper module swaps K28.1 characters received on port 0 with K28.5 as specified in the QSGMII specification.

#### VHDL

```
/simulation/k28p1_swapper_tb.vhd
```

#### Verilog

```
/simulation/k28p1_swapper_tb.v
```

The Monitor test bench module monitors the output from the DUT and verifies the data with pre loaded data structures present in the module.

#### VHDL

```
/simulation/monitor_tb.vhd
```

#### Verilog

```
/simulation/monitor_tb.v
```

The programming of per channel configuration registers in the DUT is performed through MDIO configuration test bench. There are four instances of this module with each instance representing one channel.

#### VHDL

```
/simulation/mdio_cfg_tb.vhd
```

#### Verilog

```
/simulation/mdio_cfg_tb.v
```

## Test Bench Functionality

The demonstration test bench performs the following tasks:

- Input clock signals are generated.
- A reset is applied to the example design.
- Each channel of the QSGMII core is configured through the MDIO interface by injecting an MDIO frame into the example design. This disables Auto-Negotiation and takes the core out of Isolate state.
- The speed of the interface is programmed as follows:
  - MAC mode
    - Channel 0 – 1 Gb/s
    - Channel 1 – 100 Mb/s
    - Channel 2 – 10 Mb/s
    - Channel 3 – 1 Gb/s
  - PHY mode with GMII; all channels at 1 Gb/s
  - PHY mode with MII
    - Channel 0 – 10 Mb/s
    - Channel 1 – 100 Mb/s
    - Channel 2 – 10 Mb/s
    - Channel 3 – 100 Mb/s
- The following frames are injected into the transmitter by the send frame block.
  - the first is a minimum length frame
  - the second is a type frame
  - the third is an errored frame
  - the fourth is a padded frame
- The serial data received at the device-specific transceiver transmitter interface is converted to 10-bit parallel data, then 8B/10B decoded. The resultant byte is aligned to the corresponding channel based on the K28.1 character set and also the K28.1 character set is replaced with K28.5. The resulting frames are checked by in the monitor test bench against the stimulus frames injected into the transmitter to ensure data integrity.
- The same four frames are generated by the frame generator module in the receive side of the transceiver. The data from all four instances are aggregated into 32 bits, are 8B/

10B encoded, converted to serial data, and injected into the device-specific transceiver receiver interface at 5 Gb/s.

- Data frames received at the receiver GMII interface are checked by the Monitor against the stimulus frames injected into the device-specific transceiver receiver to ensure data integrity.

---

## Customizing the Test Bench

### Changing Frame Data

You can change the contents of the four frames used by the demonstration test bench by changing the data and valid fields for each frame defined in the send frame module. New frames can be added by defining a new frame of data. Modified frames are automatically updated in both the stimulus and monitor functions.

### Changing Frame Error Status

Errors can be inserted into any of the predefined frames in any position by setting the error field to "1" in any column of that frame. Injected errors are automatically updated in both the stimulus and monitor functions.

### Changing the Core Configuration

The configuration of the QSGMII core used in the demonstration test bench can be altered.



**CAUTION!** *Certain configurations of the core cause the test bench to fail, or to cause processes to run indefinitely. For example, the demonstration test bench does not Auto-Negotiate with the design example. Determine the configurations that can safely be used with the test bench.*

The core can be reconfigured by editing the injected MDIO frame in the demonstration test bench top-level.

## Changing the Operational Speed

The speed of both the example design and test bench can be set to the desired operational speed by editing the following settings, recompiling the test bench, and then running the simulation again. The changes also need to be implemented in the example design.

### 1 Gb/s Operation

```
set speed_is_10_100_chx to logic 0
```

### 100 Mb/s Operation

```
set speed_is_10_100_chx to logic 1  
set speed_is_100_chx to logic 1
```

### 10 Mb/s Operation

```
set speed_is_10_100_chx to logic 1  
set speed_is_100_chx to logic 0
```

# Verification, Compliance, and Interoperability

This appendix provides details about how this IP core was tested for compliance.

---

## Simulation

A highly parameterizable transaction-based test bench was used to test the core. Testing included the following:

- Register Access
  - Loss of Synchronization
  - Auto-Negotiation and error handling
  - Frame Transmission and error handling
  - Frame Reception and error handling
  - Clock Compensation in the Elastic Buffers
- 

## Hardware Testing

This core has been validated with the KC705 board in only external loopback mode. Note this core has not been validated for compliance with other QSGMII vendors.

---

## Compliance Testing

This core has not been validated for compliance with other QSGMII vendors.

# Upgrading

This appendix contains information about upgrading to a more recent version of the IP core.

---

## Migrating

### Device Migration

If you are migrating from a 7 series device to an UltraScale+™ families or UltraScale™ architecture, the prefix of the optional transceiver debug ports for single-lane cores is changed from `gt0` or `gt1` to `gt`, and the postfix `_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` become `gt_gtrxreset [1:0]`.

**Note:** This is true for all ports except DRP buses, which follow the convention `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 Migration Methodology Guide* (UG1026) [Ref 16].

### Migrating to the Vivado Design Suite

For information on migrating to the Vivado Design Suite, see the *ISE to Vivado Design Suite Migration Guide* (UG911) [Ref 12].

## Upgrading in the Vivado Design Suite

This section provides information about any changes to the user logic or port designations between core versions.

In the v3.0 of the core, there have been several changes that make the core pin-incompatible with the previous version(s). These changes were required as part of the general one-off hierarchical changes to enhance the customer experience and are not likely to occur again.

### Shared Logic

As part of the hierarchical changes to the core, it is now possible to have the core itself include all of the logic that can be shared between multiple cores, which was previously exposed in the example design for the core.

If you are updating a previous version to the v3.0 with Shared Logic, there is no simple upgrade path; it is recommended to consult the Shared Logic sections of this document for more guidance.

### Port Changes from v3.3 to v3.4

Between QSGMII v4.3 and QSGMII v4.4, a single output port, `gt_powergood_out` was added. This signal indicates that CPLL calibration has been completed in the GTWIZARD. This signal should be tied to CE pin of `BUFG_GT` if used, otherwise, left open.

### Port Changes from v3.2 to v3.3

The following ports were added to the core, but only if the Transceiver Debug feature was requested during core customization. Consult the relevant transceiver user guide for more information on using these control/status ports.

Table B-1: Ports Added

Port Name and Width	In/Out	Description	What to do
<code>gt0_txinhibit_in</code>	Input	Inhibits transmission	If not used, should be tied off as specified in the transceiver guide.
<code>gt_pcsrsvdin[15:0]</code>	Input	DRP Reset. Available only for UltraScale/UltraScale+ devices.	If not used, should be tied off as specified in the transceiver guide.



## Port Changes from v3.0 to v3.1

The following ports were added to the core, but only if the Transceiver Debug feature was requested during core customization. Consult the relevant transceiver user guide for more information on using these control/status ports.

Table B-2: Ports Added

Port Name and Width	In/Out	Description	What to do
gt0_rxlpmreset_in	Input	RX LPM Reset (valid only for GTP transceivers)	If not used, should be tied off as specified in the transceiver guide.
gt0_rxlpmhfovrden_in	Input	Valid only for GTP transceivers	
gt0_dmonitorout_out[16:0]	Output	Digital Monitor to monitor state of LPM/DFE loops	
gt0_gttxreset_in	Input	Reset to start full transmit reset sequence. Present in only non UltraScale devices.	
gt0_txpcsreset_in	Input	Reset for TX PCS	
gt0_txpmarereset_in	Input	Reset for TX PMA	
gt0_gtrxreset_in	Input	Reset to start full receive reset sequence. Present in only non UltraScale devices.	
gt0_rxpcsreset_in	Input	Reset for RX PCS	
gt0_rxpmarereset_in	Input	Reset for RX PMA	
gt0_rxpmareresetdone_out	Output	Indication that RX PMA reset sequence is complete. Available only for non GTX transceivers.	
gt0_cpplllock_out	Output	Indication that CPLL has locked	
gt0_txbufstatus_out[1:0]	Output	Indicates the status of TX buffer	

## Port Changes from v2.0 to v3.0

### Ports Added

The following ports were added to the core (non-shared logic).

Table B-3: Ports Added (Non-Shared Logic)

Port Name and Width	In/Out	Description	What to do
rxoutclk	Output	rxoutclk from the Transceiver	This was previously connected internally to clocking elements and routed to rxuserclk and rxuserclk2. This can be left open if rxoutclk can be shared across instances or if not should drive clocking elements.
rxuserclk	Input	Signal from the shared logic block to the transceiver	If rxoutclk can be shared across instances, connect O/P of shared logic block. If not connect to rxoutclk after passing through additional clocking elements.
rxuserclk2	Input	Signal from the shared logic block to the transceiver	If rxoutclk can be shared across instances, connect O/P of shared logic block. If not connect to rxoutclk after passing through additional clocking elements.
gt0_pll0outclk_in	Input	Valid only for Artix <sup>®</sup> -7 families. Indicates out clock from PLL0 of GT Common.	Should be connected to signal of same name from GT Common
gt0_pll0outrefclk_in	Input	Valid only for Artix-7 families. Indicates reference out clock from PLL0 of GT Common.	Should be connected to signal of same name from GT Common
gt0_pll1outclk_in	Input	Valid only for Artix-7 families. Indicates out clock from PLL1 of GT Common.	Should be connected to signal of same name from GT Common
gt0_pll1outrefclk_in	Input	Valid only for Artix-7 families. Indicates reference out clock from PLL1 of GT Common.	Should be connected to signal of same name from GT Common
gt0_pll0lock_in	Input	Valid only for Artix-7 families. Indicates out PLL0 of GT Common has locked.	Should be connected to signal of same name from GT Common
gt0_pll0refclklost_in	Input	Valid only for Artix-7 families. Indicates out reference clock for PLL0 of GT Common is lost.	Should be connected to signal of same name from GT Common

Table B-3: Ports Added (Non-Shared Logic) (Cont'd)

Port Name and Width	In/Out	Description	What to do
gt0_pll0reset_out	output	Valid only for Artix-7 families. Reset for PLL of GT Common from reset fsm in GT Wizard	Should be connected to signal of same name from GT Common or can be left open if not needed
gt0_qplloutclk_in	Input	Valid only for non Artix-7 families. Indicates out clock from PLL of GT Common.	Should be connected to signal of same name from GT Common
gt0_qplloutrefclk_in	Input	Valid only for non Artix-7 Families. Indicates reference out clock from PLL of GT Common.	Should be connected to signal of same name from GT Common

The following ports were added to the core, but only if the transceiver debug feature was requested during core customization. Consult the relevant transceiver user guide for more information on using these control/status ports.

**Table B-4: Ports Added for Transceiver Debug Feature**

Port Name and Width	In/Out	Description	What to do
gt0_rxchariscomma_out[3:0]	Output	RX Character is Comma indication	If you want to be more compatible with the previous version of the core and also if DRP interface was not used, do not request the Transceiver Debug feature.
gt0_rxcharisk_out[3:0]	Output	RX Character is K indication	
gt0_rxbyteisaligned_out	Output	RX Byte is aligned indication	
gt0_rxbyterealign_out	Output	Rx Byte is realigned indication	
gt0_rxcommadet_out	Output	RX Comma is detected indication	
gt0_txpolarity	Input	Switch the sense of the TXN/P pins	If you want to be more compatible with the previous version of the core and also if DRP interface was not used, do not request the Transceiver Debug feature. Otherwise, drive this signal according to the relevant transceiver user guide.
gt0_txdiffctrl[3:0]	Input	Can be used to tune the transceiver TX waveform	
gt0_txprecursor[4:0]	Input	Can be used to tune the transceiver TX waveform	
gt0_txpostcursor[4:0]	Input	Can be used to tune the transceiver TX waveform	
gt0_rxpolarity	Input	Switch the sense of the RXN/P pins	
gt0_txprbssel_in[2:0]	Input	TX Pattern Generator control signals to test signal integrity	
gt0_txprbsforceerr_in	Input	TX Pattern Generator control signals to test signal integrity	
gt0_rxprbscreset_in	Input	RX Pattern Checker reset	
gt0_rxprbserr_out	Output	RX Pattern Checker error output	
gt0_rxprbssel_in[2:0]	Input	RX Pattern Checker control signals to test signal integrity	

Table B-4: Ports Added for Transceiver Debug Feature (Cont'd)

Port Name and Width	In/Out	Description	What to do
gt0_loopback_in[2:0]	Input	Loopback within transceiver	
gt0_txresetdone_out	Output	Transmitter Reset Done	
gt0_rxresetdone_out	Output	Receiver Reset Done	
gt0_rxdisperr_out[3:0]	Output	Indicates there is disparity error in received data	
gt0_rxnotintable_out[3:0]	Output	Indicates received 10 bit pattern was not found in 8B/10B decode table	
gt0_eyescanreset	Input	Reset the EYE Scan logic	
gt0_eyescantrigger	Input	Trigger the EYE Scan logic	
gt0_eyes candataerror	Output	Signals an error during Eye Scan	
gt0_rxrate[2:0]	Input	Change the PLL Divider value	
gt0_rxcdrhold	Input	Freeze the CDR loop	
gt0_rxcdrlock_out	Output	CDR loop has locked	
gt0_rxratedone_out	Output	Asserted in response to change in RXRATE	
gt0_rxlpmhfhold_in	Input	GTP Low power mode signal	
gt0_rxlplmfhold_in	Input	GTP Low power mode signal	
gt0_rxmonitorout_out[6:0]	Output	GTX/GTH RX DFE Signal	
gt0_rxmonitorsel_in[1:0]	Input	GTX/GTH RX DFE Signal	

## Ports Moved

The following ports were moved under the Transceiver Debug Feature of the core (non-shared logic). If these signals were used in the previous version, the Transceiver Debug feature needs to be enabled and the appropriate signals mapped and remaining signals tied off to default values as specified in the relevant transceiver user guide.

Table B-5: Ports Moved (non-shared logic)

In/Out	Port Name and Width	Description	What to do
Outputs	gt0_drp_busy_out, gt0_drpdo_out, gt0_drprdy_out	These signals come from the transceiver and should be connected either to an external arbiter or to the signals described in the next row.	If there is no external arbiter, connect these signals directly to the associated signals. If they interface is not used. Can be left open.
Inputs	gt0_drpen_in, gt0_drpwe_in, gt0_drpaddr_in[8:0], gt0_drpdi_i[15:0], gt0_drpclk_in	These signals go to the transceiver, either from an external arbiter or from the signals described in the previous row.	If there is no external arbiter, connect these signals directly to the associated core signals. If the interface is not used, tie off the signals to ground and gt0_drpclk_in to txusrclk2.

## Ports Removed

The following ports were removed from the core interface and are driven internally in the core.

Table B-6: Ports Removed

In/Out	Port Name and Width	Description	What to do
Input	link_timer_value_chx[8:0]	Used to configure the duration of the Auto-Negotiation Link Timer period. The duration of this timer is set to the binary number input into this port multiplied by 4096 clock periods of the 125 MHz reference clock (8 ns).	For normal operation the value of link timer is set internally to "000110010" as specified in QSGMII specification for 1.6 ms link time. To speed up simulation this value can be set internally to "000000100." This is done though xci file by the parameter EXAMPLE_SIMULATION.

# Implementing External GMII/MII

In certain applications, the client-side GMII/MII datapath can be used as a true GMII/MII to connect externally off-device across a PCB. This external GMII/MII functionality is included in the HDL block level and is seamlessly delivered with the core by the Vivado® IP catalog. This extra logic required to accomplish this is described in this Appendix.

**Note:** Virtex®-7 devices support GMII at 3.3V or lower only in certain parts and packages; see the Virtex-7 device documentation. Zynq®-7000 All Programmable SoC, Kintex®-7, and Artix®-7 devices support GMII at 3.3V or lower.

---

## External GMII Transmitter Logic

When implementing an external GMII, the GMII transmitter signals are synchronous to their own clock domain. The core must be used with a Transmitter Elastic Buffer to transfer these GMII transmitter signals onto the cores internal 125 MHz reference clock (`userclk2`). A Transmitter Elastic Buffer is embedded in the block level of the core.

Using a combination of IODELAY elements on the data and using BUFIO and BUFR regional clock routing for the `gtx_clk_chx` input clock, are illustrated in [Figure C-1](#).

In this implementation, a BUFIO is used to provide the lowest form of clock routing delay from the input clock to the input GMII TX signal sampling at the device IOBs. Note, however, that this creates placement constraints; a BUFIO capable clock input pin must be selected, and all other input GMII TX signals must be placed in the respective BUFIO region. The device FPGA user guides should be consulted.

The clock is then placed onto regional clock routing using the BUFR component and the input GMII TX data immediately resampled as illustrated.

The IODELAY elements can be adjusted to fine-tune the setup and hold times at the GMII IOB input flip-flops. The delay is applied to the IODELAY element using constraints in the XDC; these can be edited if desired.

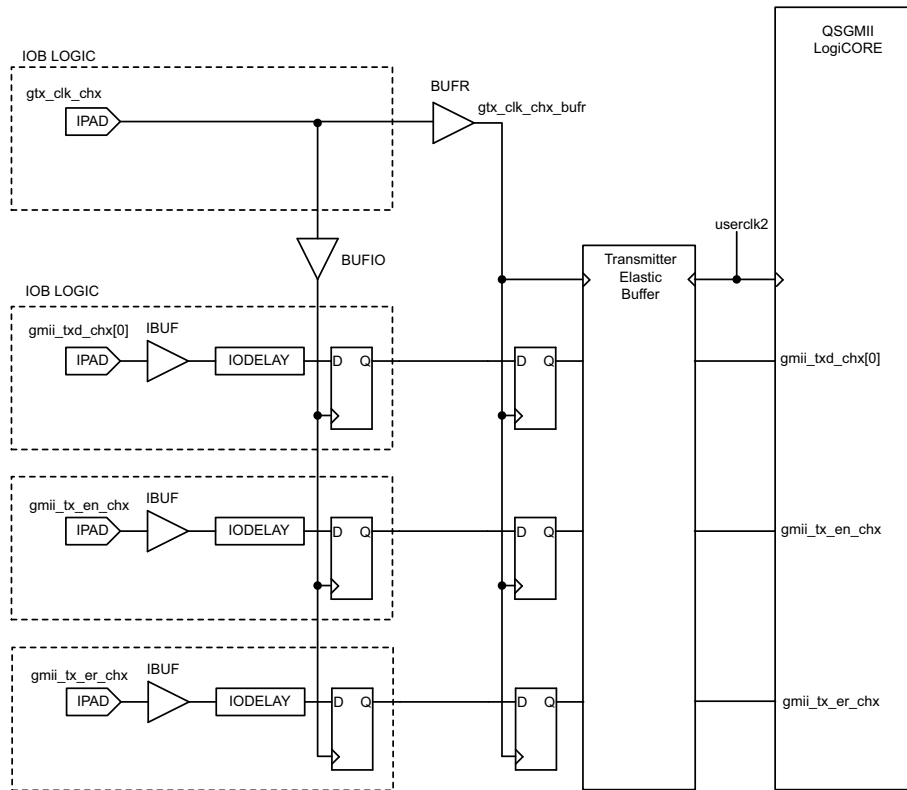


Figure C-1: External GMII Transmitter Logic

## External MII Transmitter Logic

When implementing an external MII, the MII transmitter signals are synchronous to the core internal 125 MHz clock (`userclk2`).

IODELAY elements on the data are used to delay the data by fixed duration depending on the application. The delayed data is then sampled on core internal clock (`userclk2`), as illustrated in Figure C-2.

The IODELAY elements can be adjusted to fine-tune the setup and hold times at the MII IOB input flip-flops. The delay is applied to the IODELAY element using constraints in the Example Design level XDC; these can be edited if desired.



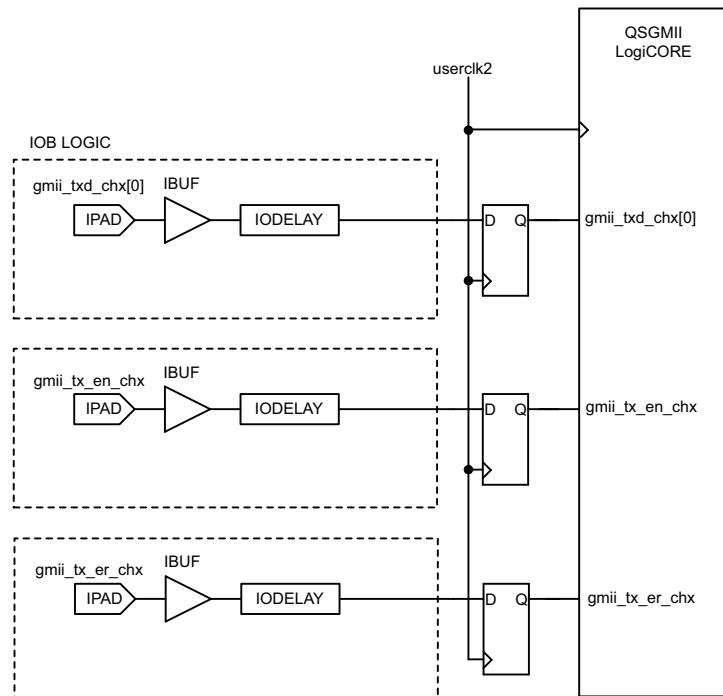


Figure C-2: External MII Transmitter Logic

## External GMII/MII Receiver Logic

Figure C-3 illustrates an external GMII receiver created in a Virtex-7 device. The signal names and logic shown in the figure exactly match those delivered in the QSGMII block when the GMII is selected. If other families are selected, equivalent primitives and logic specific to that family are automatically used in the QSGMII block.

Figure C-3 also shows that the output receiver signals are registered in device IOBs before driving them to the device pads. All receiver logic is synchronous to a single clock domain.

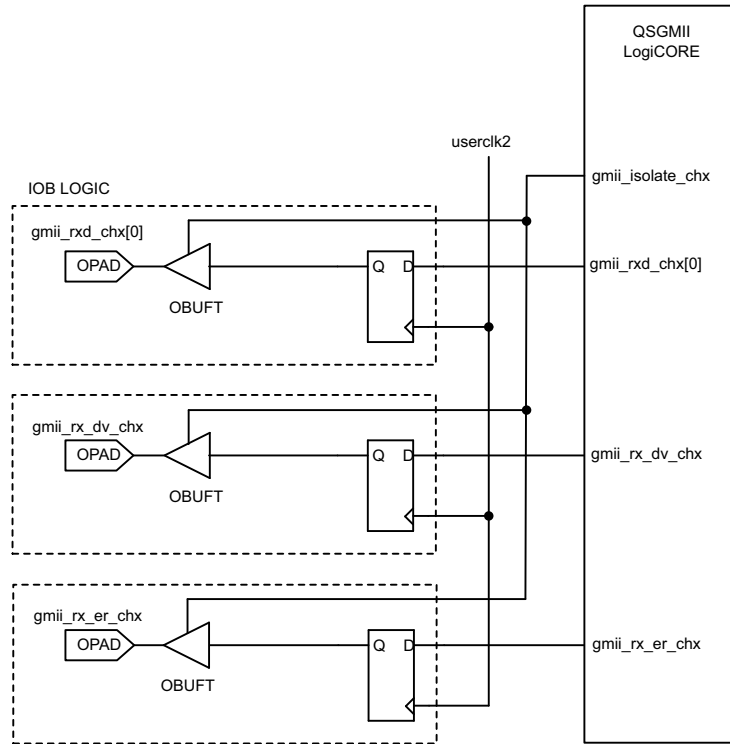


Figure C-3: External GMII/MII Receiver Logic

# Debugging

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

---

## Finding Help on Xilinx.com

To help in the design and debug process when using the QSGMII 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 QSGMII. 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 this core is located at [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 QSGMII Core**

AR [54668](#)

## **Technical Support**

Xilinx provides technical support at [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](#).

---

## Debug Tools

There are many tools available to address QSGMII core 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 Vivado Design Suite 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 with the logic debug 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) [\[Ref 13\]](#).

### Reference Boards

Various Xilinx development boards support the QSGMII core. These boards can be used to prototype designs and establish that the core can communicate with the system.

- 7 series FPGA evaluation boards:
  - KC705
  - VC707
  - AC701

# Simulation Debug

The simulation debug flow for QuestaSim is illustrated in [Figure D-1](#). A similar approach can be used with other simulators.

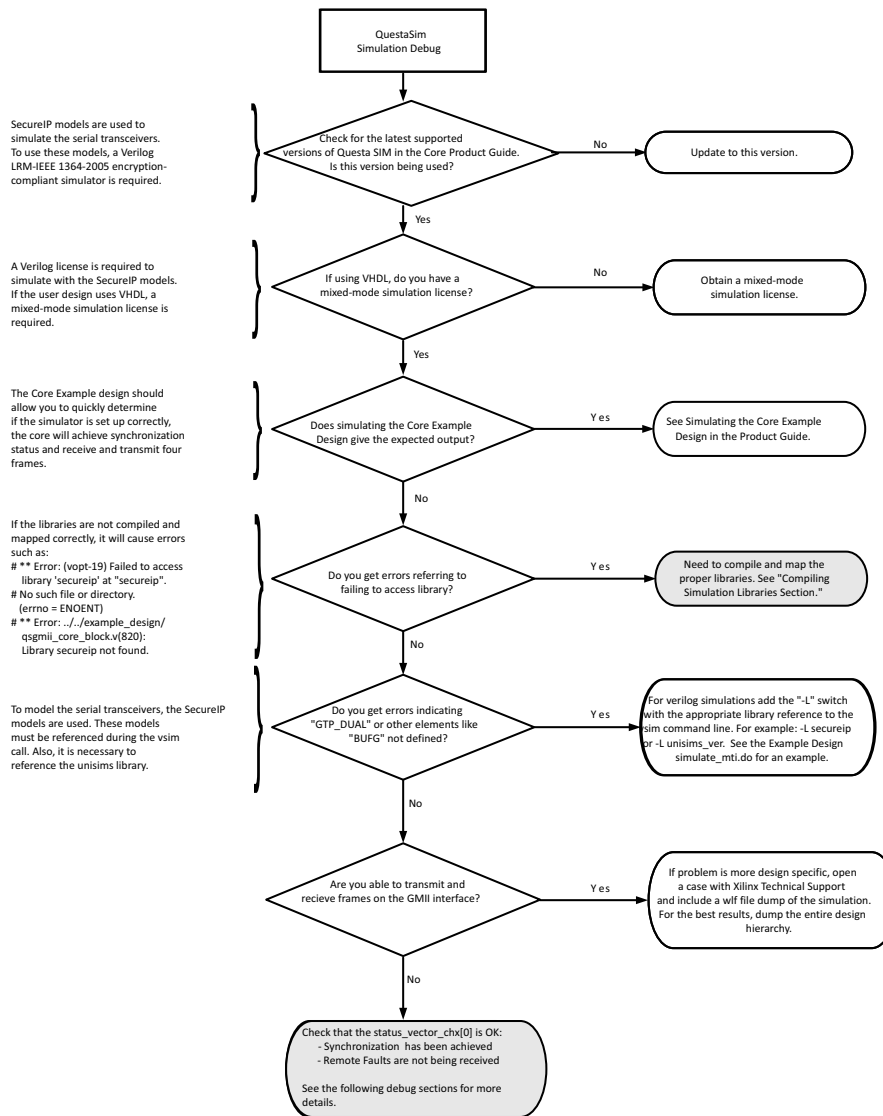


Figure D-1: Simulation Debug Flow

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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 Design Suite debug feature is a valuable resource to use in hardware debug. The signal names mentioned in the following individual sections can be probed using the Vivado Design Suite debug feature for debugging the specific problems.

Many of these common issues can also be applied to debugging design simulations. Details are provided on:

- [Problems with the MDIO](#)
- [Problems with Data Reception or Transmission](#)
- [Problems with Auto-Negotiation](#)
- [Problems in Obtaining a Link \(Auto-Negotiation Disabled\)](#)
- [Problems with a High Bit Error Rate](#)

### General Checks

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

### Problems with the MDIO

- Ensure that the MDIO is driven properly. See [MDIO Management System](#) for detailed information about performing MDIO transactions.
- Check that the `mdc` clock is running and that the frequency is 2.5 MHz or less.
- 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 PHYAD field placed into the MDIO frame matches the value placed on the `phyad[4:0]` port of the core.

## Problems with Data Reception or Transmission

When no data is being received or transmitted on a channel:

- Ensure that a valid link has been established between the core and its link partner, either by Auto-Negotiation or Manual Configuration; `status_vector_chx[0]` and `status_vector_chx[1]` should both be High. If no link has been established, see the topics discussed in the next section.

- [Problems with Auto-Negotiation](#)
- [Problems in Obtaining a Link \(Auto-Negotiation Disabled\)](#)

**Note:** Transmission through the core is not allowed unless a link has been established. This behavior can be overridden by setting the Unidirectional Enable bit.

- Ensure that the Isolate state has been disabled.

By default, the Isolate state is enabled after power-up. In the PHY mode, the PHY is electrically isolated from the GMII; for an internal GMII, it behaves as if it is isolated. This results in no data transfer across the GMII.

## Problems with Auto-Negotiation

Determine whether Auto-Negotiation has completed successfully by doing one of the following.

- Poll the Auto-Negotiation completion bit 1.5 in MDIO register 1: Status register.
- Use the Auto-Negotiation interrupt port of the core.

If Auto-Negotiation is not completing:

1. Ensure that Auto-Negotiation is enabled in both the core and in the link partner (the device or test equipment connected to the core). Auto-Negotiation cannot complete successfully unless both devices are configured to perform Auto-Negotiation.

The Auto-Negotiation procedure requires that the Auto-Negotiation handshaking protocol between the core and its link partner, which lasts for several link timer periods, occur without a bit error. A detected bit error causes Auto-Negotiation to go back to the beginning and restart. Therefore, a link with an exceptionally high bit error rate might not be capable of completing Auto-Negotiation, or might lead to a long Auto-Negotiation period caused by the numerous Auto-Negotiation restarts. If this appears to be the case, try the next step and see [Problems with a High Bit Error Rate](#).

2. Try disabling Auto-Negotiation in both the core and the link partner and see if both devices report a valid link and are able to pass traffic. If they do, it proves that the core and link partner are otherwise configured correctly. If they do not pass traffic, see [Problems in Obtaining a Link \(Auto-Negotiation Disabled\)](#).



## Problems in Obtaining a Link (Auto-Negotiation Disabled)

Determine whether the device has successfully obtained a link with its link partner by doing the following:

- Reading bit 1.2, Link Status, in MDIO register 1: Status register using the optional MDIO management interface (or look at `status_vector_chx[1]`).
- Monitoring the state of `status_vector_chx[0]`. If this is logic 1, then synchronization, and therefore a link, has been established. See Bit[0]: Link Status.

If the devices have failed to form a link then do the following:

- Ensure that Auto-Negotiation is disabled in both the core and in the link partner (the device or test equipment connected to the core).
- Monitor the state of the `signal_detect` signal 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.
  - Signal must be 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.

  - See [Problems with a High Bit Error Rate](#) in a subsequent section.

When using a device-specific transceiver, perform these additional checks:

- Ensure that the polarities of the `txn/txp` and `rxn/rxp` lines are not reversed. If they are, this can be fixed by using the `txpolarity` and `rxpolarity` ports of the device-specific transceiver.
- Check that the device-specific transceiver is not being held in reset by monitoring the `mgt_tx_reset` and `mgt_rx_reset` signals between the core and the device-specific transceiver. If these are asserted, this indicates that the PMA Phase-Locked Loop (PLL) circuitry in the device-specific transceiver has not obtained lock; check the PLL Lock signals output from the device-specific transceiver.

## Problems with a High Bit Error Rate

### Symptoms

The severity of a high-bit error rate can vary and cause any of the following symptoms:

- Failure to complete Auto-Negotiation when Auto-Negotiation is enabled.
- Failure to obtain a link when Auto-Negotiation is disabled in both the core and the link partner.
- High proportion of lost packets when passed between two connected devices that are capable of obtaining a link through Auto-Negotiation or otherwise. This can usually be accurately measured if the Ethernet MAC attached to the core contains statistic counters.

**Note:** All bit errors detected by the QSGMII Receive channel logic during frame reception show up as Frame Check Sequence Errors in an attached Ethernet MAC.

### 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 swapping the optical module on a misperforming device and repeat the tests.

Perform these additional checks when using a device-specific transceiver:

- Directly monitor the following ports of the device-specific transceiver by attaching error counters to them, or by triggering on them using the Vivado Design Suite debug feature or an external logic analyzer.

```
rxdisperr
```

```
rxnotintable
```

These signals should not be asserted over the duration of a few seconds, minutes or even hours. If they are frequently asserted, it might indicate an issue with the device-specific transceiver.

- Place the device-specific transceiver into parallel or serial loopback.
  - If the core exhibits correct operation in device-specific transceiver serial loopback, but not when loopback is performed through an optical cable, it might indicate a faulty optical module.
  - If the core exhibits correct operation in device-specific transceiver parallel loopback but not in serial loopback, this can indicate a device-specific transceiver issue.

# 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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## Documentation Navigator and Design Hubs

Xilinx® Documentation Navigator provides access to Xilinx documents, videos, and support resources, which you can filter and search to find information. To open the Xilinx Documentation Navigator (DocNav):

- From the Vivado® IDE, select **Help > Documentation and Tutorials**.
- On Windows, select **Start > All Programs > Xilinx Design Tools > DocNav**.
- At the Linux command prompt, enter `docnav`.

Xilinx Design Hubs provide links to documentation organized by design tasks and other topics, which you can use to learn key concepts and address frequently asked questions. To access the Design Hubs:

- In the Xilinx Documentation Navigator, click the **Design Hubs View** tab.
- On the Xilinx website, see the [Design Hubs](#) page.

**Note:** For more information on Documentation Navigator, see the [Documentation Navigator](#) page on the Xilinx website.

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## References

These documents provide supplemental material useful with this product guide:

1. *Cisco QSGMII Specification Version 1.2* ([EDCS-540123](#))
2. *Ethernet Standard 802.3-2008 Clauses 35, 36 and 38* ([Part 3](#))

3. Cisco Serial GMII Specification Revision 1.8 (SGMII) (<ftp://ftp-eng.cisco.com/smii/sgmii.pdf>)
4. Cisco Quad SGMII Specification Revision 1.2 (QSGMII) ([EDCS-540123](#))
5. 1G/2.5G Ethernet PCS/PMA or SGMII LogiCORE IP Product Guide ([PG047](#))
6. 7 Series FPGAs GTX/GTH Transceivers User Guide ([UG476](#))
7. 7 Series FPGAs GTP Transceivers User Guide ([UG482](#))
8. Vivado Design Suite User Guide: Designing IP Subsystems Using IP Integrator ([UG994](#))
9. Vivado Design Suite User Guide: Designing with IP ([UG896](#))
10. Vivado Design Suite User Guide: Logic Simulation ([UG900](#))
11. Vivado Design Suite User Guide: Getting Started ([UG910](#))
12. ISE to Vivado Design Suite Migration Guide ([UG911](#))
13. Vivado Design Suite User Guide: Programming and Debugging ([UG908](#))
14. Tri-Mode Ethernet MAC LogiCORE IP Product Guide ([PG051](#))
15. XST User Guide for Virtex-6, Spartan-6, and 7 Series Devices ([UG687](#))
16. UltraScale Migration Methodology Guide ([UG1026](#))

## Specifications

- IEEE 802.3-2008
- Serial-GMII Specification Revision 1.7 (CISCO SYSTEMS, ENG-46158)
- QSGMII Specification Revision 1.2 (CISCO SYSTEMS, EDCS-540123)

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## Revision History

The following table shows the revision history for this document.

Date	Version	Revision
12/20/2017	3.4	<ul style="list-style-type: none"> <li>• Added GT Data Valid signal to management registers and configuration vector interface.</li> </ul>
06/07/2017	3.4	<ul style="list-style-type: none"> <li>• Added gt_powergood_out port.</li> <li>• Removed device resource utilization tables.</li> </ul>
10/05/2016	3.3	<ul style="list-style-type: none"> <li>• Added Spartan-7 to IP Facts table.</li> <li>• Updated description in Rx Gmii Clk Source.</li> <li>• Fixed 10 Mb/s operation in Changing the Operational Speed section in Test Bench chapter.</li> </ul>

Date	Version	Revision
04/06/2016	3.3	Added support for RX path run on rxuserclk2.
11/18/2015	3.3	<ul style="list-style-type: none"> <li>• Added support for UltraScale+ families.</li> <li>• Support for Kintex UltraScale+ GTHE4 transceivers.</li> </ul>
09/30/2015	3.3	<ul style="list-style-type: none"> <li>• Updated gt0_txdifctrl_in[3:0] clock domain to Async in Transceiver Control and Status Ports.</li> <li>• Support for Zynq-7000 GTHE4 transceivers.</li> </ul>
04/01/2015	3.3	<ul style="list-style-type: none"> <li>• Updated Figs. 2-1 to 2-8.</li> <li>• Updated Table 2-15: Transceiver Control and Status Ports.</li> <li>• Added GT Port important note in Transceiver Control and Status Ports section.</li> <li>• Updated Core Customization Vivado IDE section.</li> <li>• Added Transceiver Clocking and Location in Table 6-1: Vivado IDE Parameter to User Parameter Relationship.</li> <li>• Added UNISIM important note in Simulation section.</li> <li>• Added Port Changes from v3.2 to v3.3 section in Migrating and Upgrading chapter.</li> </ul>
10/01/2014	3.2	Updated to include FPGA transceivers wizard information.
06/04/2014	3.2	Update to Migrating section in Appendix B, Migrating and Updating. User Parameters section showing relationship between Vivado IDE fields and user parameters added to Chapter 6, Design Flow Steps.
04/02/2014	3.2	<p>Updated for the 7 series device serial transceivers (TX/RX startup FSM updates).</p> <p>Changed the definition of the <code>resetdone</code> port to now indicate the completion of the RX and TX startup sequence.</p>
12/18/2013	3.1	<p>Added UltraScale™ architecture support.</p> <p>Updated serial transceivers for 7 series devices (RX/TX Startup FSM updates.)</p> <p>Increased the number of optional transceiver control and status ports</p> <p>Updated screen captures in Chapter 6.</p> <p>Changed all signal and port names in figures to all lowercase.</p>

Date	Version	Revision
10/02/2013	3.0	<p>Removed static MDIO PHY Address ports and made programmable while generation through Vivado IDE.</p> <p>Removed Link Timer ports and tied to 1.64 ms for synthesis and 0.14 ms for simulation.</p> <p>Updated for 7 series transceivers (Termination settings updates, attribute updates, hierarchy update).</p> <p>Enhanced support for IP Integrator.</p> <p>Reduced warnings in synthesis and simulation.</p> <p>Updated clock synchronizers to improve Mean Time Between Failures (MTBF) for metastability.</p> <p>Added support for the out-of-context flow.</p> <p>Added Vivado IDE option to include or exclude shareable logic resources in the core.</p> <p>Added Vivado IDE option to include or exclude configuration vector ports.</p> <p>Added optional transceiver control and status ports.</p>
03/20/2013	2.0	<p>Revision number advanced to N.N to align with core version number.</p> <p>Removed ISE-related information.</p> <p>Updated resource numbers.</p> <p>Updated Vivado IDEs</p>
10/16/2012	1.4	<p>Updated for 14.3 and 2012.3 support</p> <p>Added support for Zynq®-7000 devices</p>
07/25/2012	1.3	<p>Added Vivado tools support. Added support for Artix®-7 devices.</p>
04/24/2012	1.2	<p>Added support for Virtex®-7 FPGA GTH Transceiver.</p>
01/18/2012	1.0	<p>Initial Xilinx release</p>

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