

# CPRI v6.0 IP Core User Guide

Last updated for Quartus Prime Design Suite: 17.0 IR3, 17.0, 17.0 Update 1,  
17.0 Update 2

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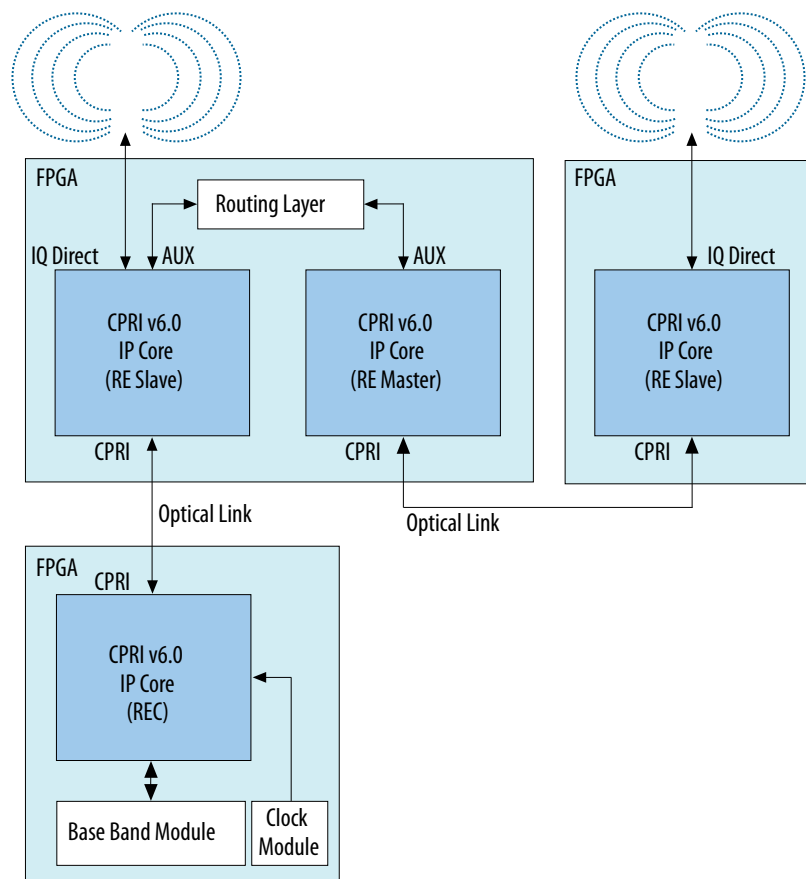
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The Common Public Radio Interface (CPRI) v6.0 Intel® FPGA IP core implements the *CPRI Specification V6.0 (2013-08-30)*. CPRI is a high-speed serial interface for network radio equipment controllers (REC) to receive data from and provide data to remote radio equipment (RE).

The CPRI v6.0 IP core targets high-performance, remote, radio network applications. You can configure the CPRI v6.0 IP core as an RE or an REC.

**Figure 1-1: Typical CPRI Application on Intel FPGA Devices**

Example system implementation with a two-hop daisy chain. Optical links between devices support high performance.



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## CPRI v6.0 IP Core Supported Features

The CPRI v6.0 IP core offers the following features:

- Compliant with the *Common Public Radio Interface (CPRI) Specification V6.0 (2013-08-30) Interface Specification* available on the CPRI Industry Initiative website ([www.cpri.info](http://www.cpri.info)).
- Supports radio equipment controller (REC) and radio equipment (RE) module configurations.
- Supports the following CPRI link features:
  - Configurable CPRI communication line bit rate (to 0.6144, 1.2288, 2.4576, 3.0720, 4.9152, 6.144, 8.11008, 9.8304, or 10.1376 Gbps) using Intel FPGA on-chip high-speed transceivers.
  - CPRI line bit rate auto-rate negotiation support.
  - Configurable and run-time programmable synchronization mode: master port or slave port on a CPRI link.
  - Scrambling and descrambling at 8.11008 and 10.1376 Gbps.
  - Optional scrambling and descrambling at 4.9152, 6.1440, and 9.8304 Gbps.
  - Transmitter (Tx) and receiver (Rx) delay measurement and calibration.
    - Optional support for single-trip delay calibration.
    - Optional round-trip delay calibration.
  - L1 link status and alarm (Z.130.0) control and status monitoring.
  - Access to all Vendor Specific data.
  - Diagnostic parallel reverse loopback paths.
  - Diagnostic serial and parallel forward loopback paths.
  - Diagnostic stand-alone slave testing mode.
- Includes the following interfaces:
  - Register access interface to external or on-chip processor, using the Intel Avalon<sup>®</sup> Memory-Mapped (Avalon-MM) interconnect specification.
  - Optional auxiliary (AUX) interface for full access to raw CPRI frame. Provides direct access to full radioframe, synchronizes the frame position with timing references, and enables routing application support from slave to master ports to implement daisy-chain topologies.
  - Optional choice of IEEE 802.3 100BASE-X compliant 10/100 Mbps MII or 1000BASE-X compliant 1Gbps GMII for Ethernet frame access.
  - Optional direct I/Q access interface enables integration of all user-defined air standard I/Q mapping schemes.
    - Optional external I/Q mapper and demapper modules with reference design support.
    - Optional external I/Q compression and decompression modules with reference design support.
  - Optional vendor specific data access interfaces provide direct access to Vendor Specific (VS), Control AxC (Ctrl\_AxC), and Real-time Vendor Specific (RTVS) subchannels.
  - Optional HDLC serial interface provides direct access to slow control and management subchannels.
  - Optional L1 inband interface provides direct access to Z.130.0 link status and alarm control word.

**Related Information**

- [CPRI Industry Initiative website](#)  
For a detailed specification of the CPRI protocol refer to the *CPRI Specification V6.0 (2013-08-30) Interface Specification* available on the CPRI Industry Initiative website.
- [Altera wiki CPRI v6.0 IP core information](#)  
Includes links to the I/Q mapper and other CPRI v6.0 IP core reference designs.
- [Intel FPGA Design Store](#)  
Includes CPRI v6.0 reference designs.

## CPRI v6.0 IP Core Device Family and Speed Grade Support

The following sections list the device family and device speed grade support offered by the CPRI v6.0 IP core:

### Device Family Support

**Table 1-1: Intel FPGA IP Core Device Support Levels**

| Device Support Level | Definition  |
|----------------------|---|
| <b>Advance</b>       | The IP core is available for simulation and compilation for this device family. Timing models include initial engineering estimates of delays based on early post-layout information. The timing models are subject to change as silicon testing improves the correlation between the actual silicon and the timing models. You can use this IP core for system architecture and resource utilization studies, simulation, pinout, system latency assessments, basic timing assessments (pipeline budgeting), and I/O transfer strategy (datapath width, burst depth, I/O standards tradeoffs). |
| <b>Preliminary</b>   | Intel has verified the IP core with preliminary timing models for this device family. The IP core meets all functional requirements, but might still be undergoing timing analysis for the device family. It can be used in production designs with caution.  |
| <b>Final</b>         | Intel has verified the IP core with final timing models for this device family. The IP core meets all functional and timing requirements for the device family and can be used in production designs.   |

**Table 1-2: CPRI v6.0 IP Core Device Family Support**

Shows the level of support offered by the CPRI v6.0 IP core for each Intel FPGA device family.

| Device Family         | Support   |
|-----------------------|---|
| Intel Stratix® 10     | <p>Advance</p> <p>Intel Stratix 10 device support is available only in the Intel Quartus® Prime Pro Edition software v17.0 IR3. It is not available in software releases 17.0, 17.0 Update 1, and 17.0 Update 2. The software release v17.0 IR3 supports only L-tile devices.</p>             |
| Intel Arria® 10       | <p>Default support level provided in the Intel Quartus Prime software. Refer to the <i>Quartus Prime Standard Edition Software and Device Support Release Notes</i> and the <i>Quartus Prime Pro Edition Software and Device Support Release Notes</i> for the relevant software release.</p> |
| Arria V (GX and GT)   | <p>Default support level provided in Intel Quartus Prime Standard Edition software. Refer to the <i>Quartus Prime Standard Edition Software and Device Support Release Notes</i> for the relevant software release.</p>   |
| Arria V GZ            | <p>Default support level provided in Intel Quartus Prime Standard Edition software. Refer to the <i>Quartus Prime Standard Edition Software and Device Support Release Notes</i> for the relevant software release.</p>   |
| Cyclone V (GX and GT) | <p>Default support level provided in Intel Quartus Prime Standard Edition software. Refer to the <i>Quartus Prime Standard Edition Software and Device Support Release Notes</i> for the relevant software release.</p>   |
| Stratix V (GX and GT) | <p>Default support level provided in Intel Quartus Prime Standard Edition software. Refer to the <i>Quartus Prime Standard Edition Software and Device Support Release Notes</i> for the relevant software release.</p>   |
| Other device families | No support  |

#### Related Information

- [CPRI v6.0 IP Core Performance: Device and Transceiver Speed Grade Support](#) on page 1-5



- **Timing and Power Models**  
Reports the default device support levels in the current version of the Intel Quartus Prime Standard Edition software.
- **Timing and Power Models**  
Reports the default device support levels in the current version of the Intel Quartus Prime Pro Edition software.

## CPRI v6.0 IP Core Performance: Device and Transceiver Speed Grade Support

**Table 1-3: Slowest Supported Device Speed Grade and Supported Transceiver Speed Grade**

Lower device speed grade numbers correspond to faster devices. The entry -x indicates that both the industrial speed grade Ix and the commercial speed grade Cx are supported for this device family and CPRI line bit rate. Table entries show slowest supported device speed grade / supported transceiver speed grade.

| Device Family    | CPRI Line Bit Rate (Gbps) |         |        |       |         |         |         |        |         |
|------------------|---------------------------|---------|--------|-------|---------|---------|---------|--------|---------|
|                  | 0.6144                    | 1.2288  | 2.4576 | 3.072 | 4.9152  | 6.1440  | 8.11008 | 9.8304 | 10.1376 |
| Intel Stratix 10 | (1)                       | -2 / -3 |        |       |         |         |         |        |         |
| Intel Arria 10   | (1)                       | -3 / -4 |        |       |         |         |         |        |         |
| Stratix V GT     | -3 / H3                   |         |        |       |         |         | -2 / H2 |        |         |
| Stratix V GX     | -4 / H3                   |         |        |       |         |         | -2 / H2 |        |         |
| Arria V GZ       | -4 / H3                   |         |        |       |         |         | -3 / H2 | (1)    |         |
| Arria V GX       | -6 / H6                   |         |        |       | -5 / H4 | -5 / H4 | (1)     |        |         |
| Arria V GT       | -5/H3                     |         |        |       |         |         | (1)     |        |         |
| Cyclone V GT     | -7 / H5                   |         |        |       |         | (1)     |         |        |         |
| Cyclone V GX     | -8 / H7                   | -7 / H6 |        |       | (1)     |         |         |        |         |

(1) The CPRI v6.0 IP core does not support this CPRI line bit rate for this device family.

## IP Core Verification

To ensure functional correctness of the CPRI v6.0 IP core, Intel performs extensive validation through both simulation and hardware testing. Before releasing a version of the CPRI v6.0 IP core, Intel runs comprehensive regression tests in the associated version of the Intel Quartus Prime software.

### Related Information

- [Knowledge Base Errata for CPRI v6.0 IP core](#)  
Some exceptions to functional correctness are documented in the CPRI v6.0 IP core errata.
- [Altera wiki CPRI v6.0 Errata page](#)  
Other exceptions to functional correctness are documented on the Altera wiki CPRI v6.0 Errata page.

## Resource Utilization for CPRI v6.0 IP Cores

Resource utilization changes depending on the parameter settings you specify in the CPRI v6.0 parameter editor. For example, with every additional interface you enable, the IP core requires additional resources to implement the module that supports that interface.

The resource utilization numbers are approximate as the Intel Quartus Prime Fitter assigns resources based on the entirety of your design. The numbers below result from a single run on a simple design. Your results may vary.

**Table 1-4: Minimum and Maximum IP Core Variations for Resource Utilization Reporting**

The IP core FPGA resource utilization table reports resource utilization for a minimum IP core variation and a maximum IP core variation. Parameters not specified remain at their default values, or their values do not affect resource utilization.

| Parameter   | Minimum Variation   | Maximum Variation                          |
|---|---|--|
| <b>Line bit rate</b>  | 1.2288 Gbps for target device in the Intel Arria 10 and Intel Stratix 10 device families, 0.6144 Gbps for all other device families | Maximum bit rate (device family dependent) |
| <b>Synchronization mode</b>   | Master  | Master                                     |
| <b>Operation mode</b>   | TX/RX Duplex  | TX/RX Duplex                               |
| <b>Core clock source input</b>  | Internal  | Internal                                   |
| <b>Receiver soft buffer depth</b>   | 4   | 8  |
| <b>Auxiliary and direct interfaces write latency cycle(s)</b>               | —   | 9  |
| Enable interface, for all optional direct interfaces in the L1 Features tab | Off   | On   |

| Parameter                                      | Minimum Variation | Maximum Variation |
|--|-------------------|-------------------|
| <b>Ethernet PCS interface</b>                  | NONE              | GMII              |
| <b>L2 Ethernet PCS Tx/Rx FIFO depth</b>        | —                 | 11                |
| <b>Enable single-trip delay calibration</b>    | Off               | Off               |
| <b>Enable round-trip delay calibration</b>     | Off               | On                |
| <b>Round-trip delay calibration FIFO depth</b> | —                 | 4                 |

**Table 1-5: IP Core FPGA Resource Utilization**

Lists the resources and expected performance for minimum and maximum variations of the CPRI v6.0 IP core in each supported device family.

These results were obtained using the Intel Quartus Prime v17.0 IR3 software on an Intel Stratix 10 device, and using the Intel Quartus Prime v17.0 software for all other target device families.

- The numbers of ALMs and logic registers are rounded up to the nearest 100.
- The numbers of ALMs, before rounding, are the **ALMs needed** numbers from the Intel Quartus Prime Fitter Report.

| Intel Stratix 10 Device (with L-Tile Transceivers) | ALMs | Logic Registers | M20K Blocks |
|--|------|-----------------|-------------|
| Minimum (1.2288 Gbps CPRI line bit rate)           | 1100 | 1600            | 2           |
| Maximum (10.1376 Gbps CPRI line bit rate)          | 4000 | 5100            | 23          |
| Intel Arria 10 Device                              | ALMs | Logic Registers | M20K Blocks |
| Minimum (1.2288 Gbps CPRI line bit rate)           | 700  | 1400            | 2           |
| Maximum (10.1376 Gbps CPRI line bit rate)          | 4000 | 5000            | 24          |
| Arria V GX or GT Device                            | ALMs | Logic Registers | M10K Blocks |
| Minimum (0.6144 Gbps CPRI line bit rate)           | 700  | 1300            | 3           |
| Maximum (6.144 Gbps CPRI line bit rate)            | 3300 | 4800            | 39          |
| Arria V GZ Device                                  | ALMs | Logic Registers | M20K Blocks |
| Minimum (0.6144 Gbps CPRI line bit rate)           | 700  | 1400            | 2           |
| Maximum (9.8304 Gbps CPRI line bit rate)           | 3700 | 5000            | 21          |

| Cyclone V GX or GT Device                 | ALMs | Logic Registers | M10K Blocks |
|---|------|-----------------|-------------|
| Minimum (0.6144 Gbps CPRI line bit rate)  | 700  | 1400            | 2           |
| Maximum (4.9512 Gbps CPRI line bit rate)  | 4100 | 5800            | 27          |
| Stratix V GX or GT Device                 | ALMs | Logic Registers | M20K Blocks |
| Minimum (0.6144 Gbps CPRI line bit rate)  | 700  | 1400            | 2           |
| Maximum (10.1376 Gbps CPRI line bit rate) | 3700 | 5500            | 20          |

**Related Information****[Fitter Resources Reports in the Intel Quartus Prime Help](#)**

Information about Intel Quartus Prime resource utilization reporting, including **ALMs needed**.

## Release Information

**Table 1-6: CPRI v6.0 IP Core Current Release Information**

| Item  | Description                                      |
|---|--|
| Compatible Intel Quartus Prime Software Version | 17.0 IR3, 17.0, 17.0 Update 1, and 17.0 Update 2 |
| Release Date                                    | 2017.08.07                                       |
| Ordering Codes                                  | IP-CPRI-V6                                       |

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Explains how to install, parameterize, and simulate the CPRI v6.0 IP core.

## **Installation and Licensing** on page 2-2

The CPRI v6.0 IP core is an extended FPGA IP core which is not included with the Intel Quartus Prime release. This section provides a general overview of the Intel extended FPGA IP core installation process to help you quickly get started with any Intel extended FPGA IP core.

## **Generating CPRI v6.0 IP Cores** on page 2-3

After you install and integrate the extended IP core in the ACDS release, the CPRI v6.0 IP core supports the standard customization and generation process. This IP core does not generate a testbench or example design simultaneously with generation of the IP core. Instead, you must use the Example Design button in the CPRI v6.0 parameter editor to generate the testbench. This IP core is not supported in Qsys.

## **CPRI v6.0 IP Core File Structure** on page 2-3

The Intel Quartus Prime software generates the following IP core output file structure.

## **CPRI v6.0 IP Core Parameters** on page 2-7

The CPRI v6.0 parameter editor provides the parameters you can set to configure the CPRI v6.0 IP core and simulation testbench.

## **Integrating Your IP Core in Your Design: Required External Blocks** on page 2-17

You must connect your CPRI v6.0 IP core to some additional required design components. Your design can simulate and compile without some of these connections and logical blocks, but it will not function correctly in hardware unless all of them are present and connected in your design.

## **Simulating Intel FPGA IP Cores** on page 2-25

The Intel Quartus Prime software supports RTL- and gate-level design simulation of Intel FPGA IP cores in supported EDA simulators. Simulation involves setting up your simulator working environment, compiling simulation model libraries, and running your simulation.

## **Understanding the Testbench** on page 2-26

Intel provides a demonstration testbench with the CPRI v6.0 IP core.

## **Running the Testbench** on page 2-26

To run the CPRI v6.0 IP core demonstration testbench, follow these steps.

## **Compiling the Full Design and Programming the FPGA** on page 2-28

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**Related Information****Introduction to Intel FPGA IP Cores**

Additional information about generating an Intel FPGA IP core and integrating it in your Intel Quartus Prime project.

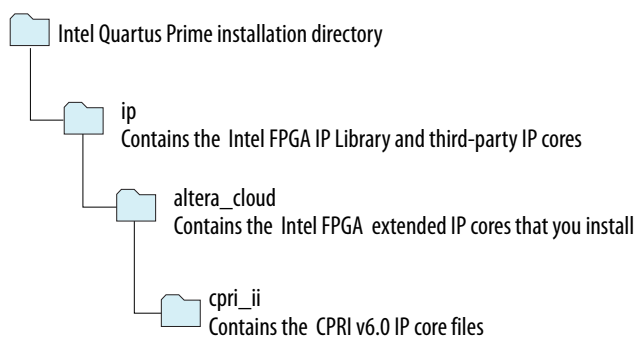
## Installation and Licensing

The CPRI v6.0 IP core is an extended FPGA IP core which is not included with the Intel Quartus Prime release. This section provides a general overview of the Intel extended FPGA IP core installation process to help you quickly get started with any Intel extended FPGA IP core.

The Intel extended FPGA IP cores are available from the Altera Self-Service Licensing Center (SSLC). Refer to Related Information below for the correct link for this IP core.

**Figure 2-1: IP Core Installation Directory Structure**

Directory structure after you install the CPRI v6.0 IP core.



**Table 2-1: IP Core Installation Locations**

| Location   | Software                             | Platform |
|--|--------------------------------------|----------|
| <code>&lt;drive&gt;:\intelFPGA_pro&lt;version&gt;\quartus\ip\altera_cloud</code>           | Intel Quartus Prime Pro Edition      | Windows* |
| <code>&lt;drive&gt;:\intelFPGA&lt;version&gt;\quartus\ip\altera_cloud</code>               | Intel Quartus Prime Standard Edition | Windows  |
| <code>&lt;home directory&gt;:/intelFPGA_pro/&lt;version&gt;/quartus/ip/altera_cloud</code> | Intel Quartus Prime Pro Edition      | Linux*   |
| <code>&lt;home directory&gt;:/intelFPGA/&lt;version&gt;/quartus/ip/altera_cloud</code>     | Intel Quartus Prime Standard Edition | Linux    |

**Related Information**

- [Intel FPGA website](#)

- **Self-Service Licensing Center (SSLC)**

After you purchase the CPRI v6.0 IP core, the IP core is available for download from the SSLC page in your myAltera account. You must create a myAltera account if you do not have one already, and log in to access the SSLC. On the SSLC page, click Run for this IP core. The SSLC provides an installation dialog box to guide your installation of the IP core.

## Generating CPRI v6.0 IP Cores

You can quickly configure a custom IP variation in the parameter editor. Use the following steps to specify CPRI v6.0 IP core options and parameters in the parameter editor.

1. In the IP Catalog (**Tools > IP Catalog**), locate and double-click the name **CPRI v6.0**. The parameter editor appears.
2. Specify a top-level name for your custom IP variation. The parameter editor saves the IP variation settings in a file named `<your_ip>.qsys` (in Intel Quartus Prime Standard Edition) or `<your_ip>.ip` (in Intel Quartus Prime Pro Edition). Click **OK**.
3. Specify the parameters and options for your IP variation in the parameter editor, including one or more of the following. Refer to "IP Core Parameters" for information about specific IP core parameters.
  - Specify parameters defining the IP core functionality, port configurations, and device-specific features.
  - Specify options for processing the IP core files in other EDA tools.
4. Click **Generate HDL**. The **Generation** dialog box appears.
5. Specify output file generation options, and then click **Generate**. The IP variation files generate according to your specifications.
6. To generate a simulation testbench, click **Generate Example Design**. Please refer to the instructions in the *Running the Testbench* section.
7. To generate an HDL instantiation template that you can copy and paste into your text editor, click **Generate > Show Instantiation Template**.
8. Click **Finish**. The parameter editor adds the top-level `.qsys` or `.ip` file to the current project automatically. If you are prompted to manually add the `.qsys` file to the project, click **Project > Add/Remove Files in Project** to add the file.
9. After generating and instantiating your IP variation, make appropriate pin assignments to connect ports.

## CPRI v6.0 IP Core File Structure

The Intel Quartus Prime software generates the following IP core output file structure.

Figure 2-2: IP Core Generated Files

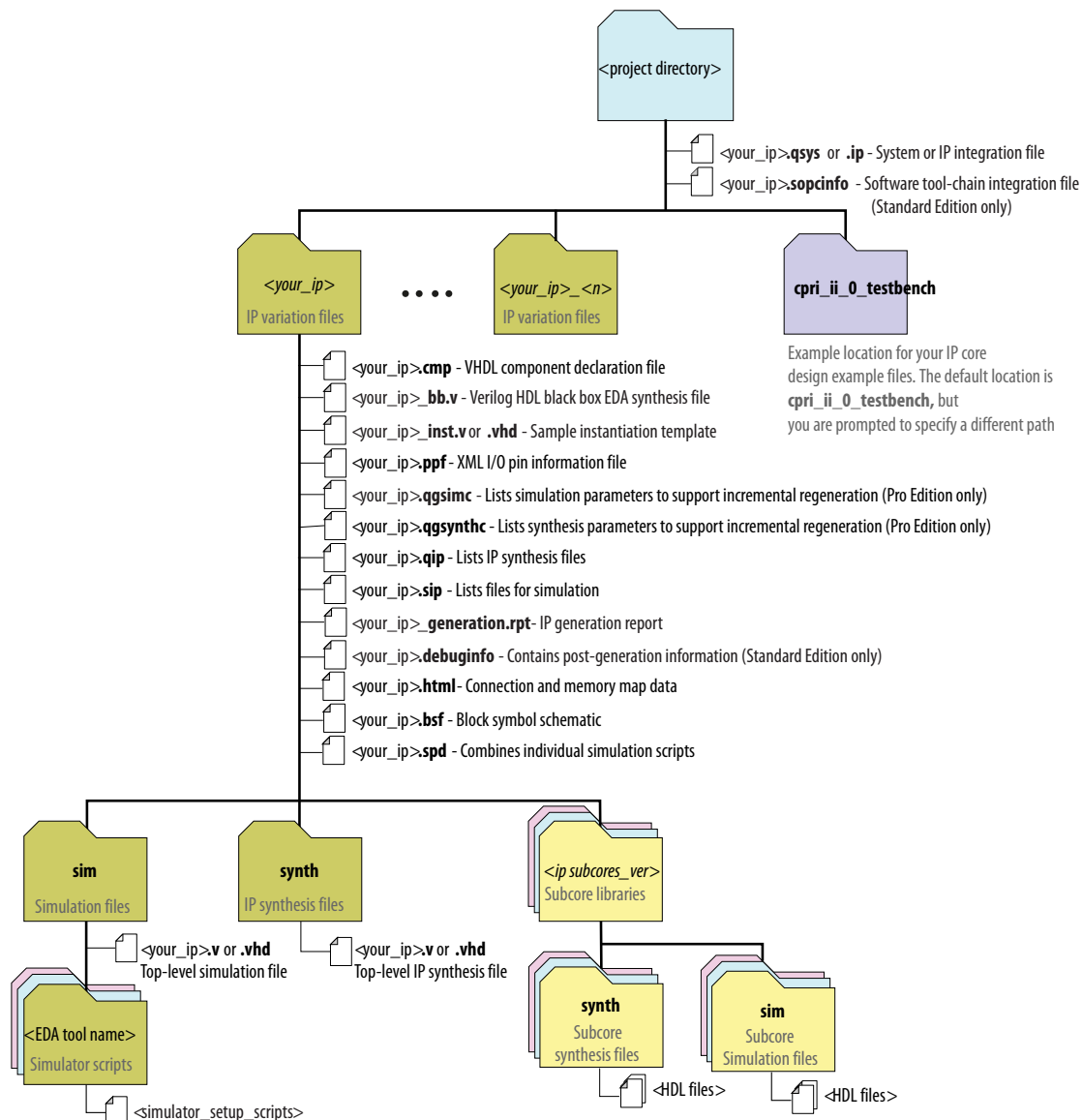


Table 2-2: IP Core Generated Files

| File Name  | Description  |
|--|--|
| <your_ip>.qsys (Intel Quartus Prime Standard Edition only) | The Qsys system or top-level IP variation file. <your_ip> is the name that you give your IP variation. |
| <your_ip>.ip (Intel Quartus Prime Pro Edition only)        |  |



| File Name                                   | Description   |
|---|---|
| <code>&lt;system&gt;.sopcinfo</code>        | <p>Describes the connections and IP component parameterizations in your Qsys system. You can parse its contents to get requirements when you develop software drivers for IP components. (Intel Quartus Prime Standard Edition only)</p> <p>Downstream tools such as the Intel Nios<sup>®</sup> II tool chain use this file. The <code>.sopcinfo</code> file and the <code>system.h</code> file generated for the Nios II tool chain include address map information for each slave relative to each master that accesses the slave. Different masters may have a different address map to access a particular slave component.</p> |
| <code>&lt;your_ip&gt;.cmp</code>            | The VHDL Component Declaration ( <b>.cmp</b> ) file is a text file that contains local generic and port definitions that you can use in VHDL design files.  |
| <code>&lt;your_ip&gt;.html</code>           | A report that contains connection information, a memory map showing the address of each slave with respect to each master to which it is connected, and parameter assignments.  |
| <code>&lt;your_ip&gt;_generation.rpt</code> | IP or Qsys generation log file. A summary of the messages during IP generation.   |
| <code>&lt;your_ip&gt;.debuginfo</code>      | Contains post-generation information. Used to pass System Console and Bus Analyzer Toolkit information about the Qsys interconnect. The Bus Analysis Toolkit uses this file to identify debug components in the Qsys interconnect. (Intel Quartus Prime Standard Edition only)  |
| <code>&lt;your_ip&gt;.qgsimc</code>         | Lists simulation parameters to support incremental regeneration. (Intel Quartus Prime Pro Edition only)   |
| <code>&lt;your_ip&gt;.qgsynthc</code>       | Lists synthesis parameters to support incremental regeneration. (Intel Quartus Prime Pro Edition only)  |
| <code>&lt;your_ip&gt;.qip</code>            | Contains all the required information about the IP component to integrate and compile the IP component in the Quartus Prime software.   |
| <code>&lt;your_ip&gt;.csv</code>            | Contains information about the upgrade status of the IP component.  |
| <code>&lt;your_ip&gt;.bsf</code>            | A Block Symbol File ( <b>.bsf</b> ) representation of the IP variation for use in Quartus Prime Block Diagram Files ( <b>.bdf</b> ).  |
| <code>&lt;your_ip&gt;.spd</code>            | Required input file for <code>ip-make-simscript</code> to generate simulation scripts for supported simulators. The <b>.spd</b> file contains a list of files generated for simulation, along with information about memories that you can initialize.  |
| <code>&lt;your_ip&gt;.ppf</code>            | The Pin Planner File ( <b>.ppf</b> ) stores the port and node assignments for IP components created for use with the Pin Planner.   |
| <code>&lt;your_ip&gt;_bb.v</code>           | You can use the Verilog black-box ( <b>_bb.v</b> ) file as an empty module declaration for use as a black box.  |

| File Name   | Description  |
|---|--|
| <code>&lt;your_ip&gt;.sip</code>  | Contains information required for NativeLink simulation of IP components. You must add the <b>.sip</b> file to your Intel Quartus Prime project.   |
| <code>&lt;your_ip&gt;_inst.v</code> and <code>_inst.vhd</code>            | HDL example instantiation template. You can copy and paste the contents of this file into your HDL file to instantiate the IP variation.   |
| <code>&lt;your_ip&gt;.regmap</code>                                       | If IP contains register information, <b>.regmap</b> file generates. The <b>.regmap</b> file describes the register map information of master and slave interfaces. This file complements the <b>.sopcinfo</b> file by providing more detailed register information about the system. This enables register display views and user customizable statistics in the System Console.   |
| <code>&lt;your_ip&gt;.svd</code>  | Allows hard processor system (HPS) System Debug tools to view the register maps of peripherals connected to HPS within a Qsys system.<br><br>During synthesis, the <b>.svd</b> files for slave interfaces visible to System Console masters are stored in the <b>.sof</b> file in the debug section. System Console reads this section, which Qsys can query for register map information. For system slaves, Qsys can access the registers by name. |
| <code>&lt;your_ip&gt;.v</code><br>and<br><code>&lt;your_ip&gt;.vhd</code> | HDL files that instantiate each submodule or child IP core for synthesis or simulation.  |
| <code>mentor/</code>  | Contains a ModelSim script <code>msim_setup.tcl</code> to set up and run a simulation.   |
| <code>aldec/</code>   | Contains a Riviera-PRO script <code>rivierapro_setup.tcl</code> to setup and run a simulation.   |
| <code>synopsys/vcs/</code><br><code>synopsys/vcsmx/</code>                | Contains a shell script <code>vcs_setup.sh</code> to set up and run a VCS® simulation.<br><br>Contains a shell script <code>vcsmx_setup.sh</code> and <code>synopsys_sim.setup</code> file to set up and run a VCS MX® simulation.   |
| <code>cadence/</code>   | Contains a shell script <code>ncsim_setup.sh</code> and other setup files to set up and run an NCSIM simulation.   |
| <code>submodules/</code>  | Contains HDL files for the IP core submodule.  |
| <code>&lt;child IP cores&gt;/</code>                                      | For each generated child IP core directory, Qsys generates <code>synth/</code> and <code>sim/</code> sub-directories.  |

## CPRI v6.0 IP Core Parameters

The CPRI v6.0 parameter editor provides the parameters you can set to configure the CPRI v6.0 IP core and simulation testbench.

The CPRI v6.0 parameter editor has three tabs.

**Table 2-3: General CPRI v6.0 IP Core Parameters**

Describes the general parameters for customizing the CPRI v6.0 IP core. These parameters appear on the **General** tab in the CPRI v6.0 parameter editor.

| Parameter                      | Options   | Default Setting                                 | Parameter Description  |
|--------------------------------|---|---|--|
| <b>Line bit rate (Mbits/s)</b> | <ul style="list-style-type: none"> <li>614.4</li> <li>1228.8</li> <li>2457.6</li> <li>3072.0</li> <li>4915.2</li> <li>6144.0</li> <li>8110.08</li> <li>9830.4</li> <li>10137.6</li> </ul> | Lowest bit rate supported for the device family | <p>Selects the CPRI line bit rate. Refer to <a href="#">CPRI v6.0 IP Core Performance: Device and Transceiver Speed Grade Support</a> on page 1-5 for supported CPRI line bit rates in the supported device families.</p> <p>The parameter editor does not allow you to specify a CPRI line bit rate that the target device does not support.</p>  |
| <b>Synchronization mode</b>    | <ul style="list-style-type: none"> <li>Master</li> <li>Slave</li> </ul>   | Master  | <p>Specifies whether the CPRI v6.0 IP core is configured as a CPRI link master or a CPRI link slave.</p> <p>The value of this parameter determines the initial and reset clocking mode of the CPRI v6.0 IP core. You can modify the IP core clocking mode dynamically by modifying the value of the <code>synchronization_mode</code> field of the <code>L1_CONFIG</code> register.</p>  |
| <b>Operation mode</b>          | <ul style="list-style-type: none"> <li>TX/RX Duplex</li> <li>TX Simplex</li> <li>RX Simplex</li> </ul>  | TX/RX Duplex                                    | <p>Specifies whether the CPRI v6.0 IP core is configured with RX functionality only (RX Simplex), with TX functionality only (TX Simplex), or with both RX and TX functionality (TX/RX Duplex).</p> <p>If you specify a simplex mode, the Quartus Prime Fitter synthesizes logic for only one direction of traffic. If the CPRI v6.0 IP core is in TX simplex operation mode, it can transmit on the CPRI link but cannot receive. If the CPRI v6.0 IP core is in RX simplex operation mode, it can receive traffic on the CPRI link but cannot transmit.</p> <p>Currently, IP core variations that target an Intel Stratix 10 device support only the <b>TX/RX Duplex</b> mode.</p> |

| Parameter                                      | Options  | Default Setting | Parameter Description  |
|--|--|-----------------|--|
| <b>Core clock source input</b>                 | <ul style="list-style-type: none"> <li>External</li> <li>Internal</li> </ul>         | Internal        | <p>Specifies the clock source of the <code>cpri_coreclk</code>.</p> <p>In the internal clocking scheme, you should drive the <code>cpri_coreclk</code> with the cleaned-up <code>xcvr_recovered_clk</code> in CPRI slave IP cores, and with the external master clock in CPRI master IP cores. In this clocking scheme, the IP core uses the <code>cpri_coreclk</code> input clock only when the IP core is running at the CPRI line bit rate of 8.11008 or 10.1376 Gbps,</p> <p>The external clocking scheme supports the single-trip delay calibration feature. In this clocking scheme, the IP core uses this clock at all CPRI line bit rates. You can drive the <code>cpri_coreclk</code> input clock with the <code>tx_clkout</code> output clock from the TX PCS.</p> |
| <b>Transmitter local clock division factor</b> | <ul style="list-style-type: none"> <li>1</li> <li>2</li> <li>3</li> <li>4</li> </ul> | 1               | <p>Specifies the division factor for the local clock divider. The IP core divides the high speed clock from the transceiver TX PLL (<code>xcvr_ext_pll_clk</code>) to generate the serial TX clock.</p> <p>This feature supports the configuration of multiple instances of the CPRI v6.0 IP core that run at different CPRI line bit rates but share use of the same TX PLL.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>RX Simplex</b>.</p> <p>IP core variations that target an Intel Arria 10 device or an Intel Stratix 10 device, with <b>Line bit rate</b> set to 4915.2 Mbps or slower, support only the value of 1.</p>  |

| Parameter  | Options  | Default Setting | Parameter Description  |
|--|--|-----------------|--|
| <p><b>Number of receiver CDR reference clock(s)</b></p>    | <ul style="list-style-type: none"> <li>• 1</li> <li>• 2</li> </ul> | <p>1</p>        | <p>Specifies the width of the receiver reference clock that controls the receiver. The CPRI v6.0 IP core supports the selection of one or two clocks. This option supports auto-negotiation to and from the CPRI line bit rate of 10.1376 Gbps in CPRI v6.0 IP core variations that target a Stratix V device. Refer to "IP Core Clocking Structure."</p> <p>If you set this parameter to the value of <b>1</b>, the <code>xcvr_cdr_refclk</code> is a single clock. If you set this parameter to the value of <b>2</b>, the <code>xcvr_cdr_refclk</code> input signal is two bits wide, to support two distinct reference clocks.</p> <p>Intel recommends that you specify a two-bit clock for Stratix V variations that are expected to implement auto-negotiation up to a 10.1376 Gbps CPRI line bit rate. In this case the typical design drives one bit of the <code>xcvr_cdr_refclk</code> clock with a common 307.2 MHz clock for the lower CPRI line bit rates and drives the other bit with a 253.44 MHz clock for the 10.1376 Gbps CPRI line bit rate. However, these specific clock frequencies are not required.</p> <p>If the value of this parameter is 2, the receiver clocks the CDR with the <code>xcvr_cdr_refclk[0]</code> input signal by default. You can switch the receiver to use <code>xcvr_cdr_refclk[1]</code>, or back to <code>xcvr_cdr_refclk[0]</code>, by dynamically reconfiguring the RX transceiver.</p> <p>IP core variations that target a device family other than the Stratix V device family, support only a single-bit receiver reference clock.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b>.</p> |
| <p><b>Receiver CDR reference clock frequency (MHz)</b></p> | <p>Per drop-down menu</p>  | <p>307.2</p>    | <p>Specifies the incoming reference clock frequency for the receiver CDR PLL, in MHz.</p> <p>You must drive the input clock <code>xcvr_cdr_refclk</code> or <code>xcvr_cdr_refclk[0]</code> at the frequency you specify for this parameter.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b>.</p>  |

| Parameter   | Options  | Default Setting | Parameter Description   |
|---|--|-----------------|---|
| <b>VCCR_GXB and VCCT_GXB supply voltage for the transceiver</b> | <ul style="list-style-type: none"> <li>1_1V</li> <li>1_0V</li> </ul> | 1_0V            | <p>Specifies whether the transceiver supply voltage is 1.1 V or 1.0 V. The supply voltage must match the voltage you specify for this parameter, in IP core variations that target an Intel Stratix 10 device.</p> <p>This parameter affects only IP core variations that target an Intel Stratix 10 device. You can ignore it for other device families.</p>   |
| <b>Recovered clock source</b>                                   | <ul style="list-style-type: none"> <li>PCS</li> <li>PMA</li> </ul>   | PCS             | <p>Specifies the clock source of the <code>xcvr_recovered_clk</code>.</p> <p>Intel recommends that you set this parameter to the value of <b>PMA</b> in IP core variations that target a Stratix V device, if you expect your IP core to auto-negotiate to or from the CPRI line bit rate of 10.1376 Gbps. In this case, sourcing the recovered clock from the PMA improves jitter on that clock. If you specify the PCS source, the IP core switches between two PCS-internal clocks at auto-negotiation to or from the CPRI line bit rate of 10.1376 Gbps.</p> <p>This parameter is not available for</p> <ul style="list-style-type: none"> <li>CPRI master IP cores</li> <li>IP cores that target an Intel Stratix 10 device</li> <li>IP cores for which you set the value of <b>Operation mode</b> to <b>TX Simplex</b></li> </ul>   |
| <b>Receiver soft buffer depth</b>                               | 4, 5, 6, 7, or 8   | 6               | <p>The value you specify for this parameter is <math>\log_2</math> of the IP core Layer 1 Rx buffer depth. The IP core supports a maximum Layer 1 RX buffer depth of 256.</p> <p>The default depth of the buffer is 64, specified by the parameter default value of 6. For most systems, the default buffer depth is adequate to handle dispersion, jitter, and drift that can occur on the link while the system is running. However, the parameter is available for cases in which additional depth is required.</p> <p>Increasing the value of this parameter increases resource utilization. Increasing the value of this parameter affects latency only when the buffer fills beyond the default capacity. In that case, the larger buffer increases latency but prevents data loss.</p> <p>The user guide refers to this parameter value as <code>RX_BUF_DEPTH</code>.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b>.</p> |

| Parameter   | Options   | Default Setting | Parameter Description   |
|---|---|-----------------|---|
| <b>Enable line bit rate auto-negotiation</b>                    | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on the <b>Enable line bit rate auto-negotiation</b> parameter to specify that your CPRI v6.0 IP core supports auto-rate negotiation.</p> <p>If you turn on this parameter, your IP core does not implement auto-negotiation. You must dynamically reconfigure the transceiver to modify the CPRI line bit rate and implement auto-negotiation. However, if you turn off this parameter, the IP core does not support bit line rate auto-negotiation, and you cannot modify the CPRI line bit rate dynamically.</p> <p>If you turn off this parameter and also turn off <b>Enable start-up sequence state machine</b>, <b>Enable single-trip delay calibration</b>, and in Intel Arria 10 devices, the <b>Enable ADME, transceiver capability, control and status registers access</b>, the transceiver reconfiguration interface is not available.</p> <p>This parameter is available when you specify a CPRI line bit rate (value for the <b>Line bit rate</b> parameter) that is greater than 614.4 Mbps. This parameter is not yet available for Intel Stratix 10 devices.</p> |
| <b>Enable line bit rate auto-negotiation down to 614.4 Mbps</b> | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to specify that your auto-rate negotiation enabled CPRI v6.0 IP core can support auto-rate negotiation all the way down to the CPRI line bit rate of 0.6144 Gbps.</p> <p>This parameter is available for devices that support a CPRI line bit rate of 614.4 Mbps, and when you turn on <b>Enable line bit rate auto-negotiation</b>.</p>  |

**Table 2-4: CPRI v6.0 IP Core Interface Feature Parameters**

Describes the parameters for customizing the CPRI v6.0 IP core Layer 1 and Layer 2 interfaces and testing features. These parameters appear on the **Interfaces** tab in the CPRI v6.0 parameter editor.

| Parameter                                  | Options  | Default Setting | Parameter Description   |
|--|--|-----------------|---|
| <b>L1 Features</b>                         |  |                 |   |
| <b>Management (CSR) interface standard</b> | Currently, only the Avalon-MM CPU interface is available in the CPRI v6.0 IP core. |                 | Selects the interface specification that describes the behavior of the CPRI v6.0 IP core register access interface. |

| Parameter   | Options  | Default Setting | Parameter Description  |
|---|--|-----------------|--|
| <b>Avalon-MM interface addressing type</b>                    | <ul style="list-style-type: none"> <li>Word</li> <li>Byte</li> </ul> | Word            | Specifies the addressing mode for the Avalon-MM CPU interface. If the addressing mode is <b>Word</b> , you must ensure you correctly align the connections between Avalon-MM components. This parameter specifies how other components must connect to the <code>cpu_address</code> bus on the CPU interface.  |
| <b>Auxiliary and direct interfaces write latency cycle(s)</b> | 0 to 9   | 0               | <p>Specifies the additional write latency on the AUX TX interface and other direct TX interfaces to the CPRI v6.0 IP core. The write latency is the number of <code>cpri_clkout</code> cycles from when the <code>aux_tx_seq</code> output signal has the value of 0 to when user logic writes data to the AUX TX interface. For other direct interfaces, the IP core notifies user logic when it is ready for input and the user does not need to monitor the <code>aux_tx_seq</code> signal.</p> <p>When <b>Auxiliary and direct interfaces write latency cycle(s)</b> has the value of zero, the write latency on the direct TX interfaces is one <code>cpri_clkout</code> cycle. When <b>Auxiliary and direct interfaces write latency cycle(s)</b> has the value of N, the write latency is (1+N) <code>cpri_clkout</code> cycles.</p> <p>Set this parameter to a value that provides user logic with sufficient advance notice of the position in the CPRI frame. The processing time that user logic requires after determining the current position in the CPRI frame is implementation specific.</p> <p>This parameter is available if you turn on at least one direct interface in your CPRI v6.0 IP core variation.</p> |
| <b>Enable auxiliary interface</b>                             | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul>    | Off             | Turn on this parameter to include the AUX interface in your CPRI v6.0 IP core. The AUX interface provides full access to the raw CPRI frame.   |



| Parameter  | Options   | Default Setting | Parameter Description   |
|--|---|-----------------|---|
| <b>Enable all control word access via management interface</b> | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to enable access to all control words in a hyperframe using the CPRI v6.0 CTRL_INDEX, TX_CTRL, and RX_CTRL registers.</p> <p>Use this option with caution. During transmission, this feature has higher priority than the MII, the GMII, the HDLC serial interface, the L1 control and status interface, and the generation of special symbols (K28.5, D16.2, /S/, /T/), and can overwrite standard control words in the hyperframe.</p>  |
| <b>Enable direct Z.130.0 alarm bits access interface</b>       | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to include a dedicated L1 control and status interface to communicate the contents of the CPRI frame Z.130.0 word, which includes alarms and reset signals.</p>   |
| <b>Enable direct ctrl_axc access interface</b>                 | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to include a dedicated interface to access the Ctrl_AxC subchannels in the CPRI frame.</p>  |
| <b>Enable direct vendor specific access interface</b>          | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to include a dedicated interface to access the VS subchannels in the CPRI frame.</p>  |
| <b>Enable direct real-time vendor specific interface</b>       | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to include a dedicated interface to access the RTVS subchannel in the CPRI frame.</p> <p>This parameter is available when you specify a CPRI line bit rate of 10137.6 Mbps.</p>   |
| <b>Enable start-up sequence state machine</b>                  | <ul style="list-style-type: none"> <li>• On</li> <li>• Off</li> </ul> | Off             | <p>Turn on this parameter to include a start-up sequence state machine in the CPRI v6.0 IP core.</p> <p>If you turn off this parameter and also turn off <b>Enable line bit rate auto-negotiation</b>, <b>Enable single-trip delay calibration</b>, and in Intel Arria 10 and Intel Stratix 10 devices, the <b>Enable ADME, transceiver capability, control and status registers access</b>, the transceiver reconfiguration interface is not available.</p> <p>This parameter is available if you set the value of <b>Operation mode</b> to <b>TX/RX Duplex</b>.</p> |

| Parameter   | Options   | Default Setting | Parameter Description   |
|---|---|-----------------|---|
| <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul>                 | Off             | <p>Turn on this parameter to include a negotiator block that performs auto-negotiation of L1 inband protocol version (communicated in CPRI frame position Z.2.0) and L2 C&amp;M rates (communicated in CPRI frame positions Z.66.0 and Z.194.0).</p> <p>This parameter is available when you turn on <b>Enable start-up sequence state machine</b>.</p>   |
| <b>Enable direct I/Q mapping interface</b>                                  | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul>                 | Off             | Turn on this parameter to include a dedicated interface to access the raw I/Q data bytes in the CPRI frame.   |
| <b>L2 Features</b>  |   |                 |   |
| <b>Enable HDLC serial interface</b>   | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul>                 | Off             | <p>Turn on this parameter to include a dedicated interface to communicate the contents of the slow C&amp;M subchannels.</p> <p>For full HDLC communication, you must connect a user-defined HDLC module to this interface.</p>  |
| <b>Ethernet PCS interface</b>   | <ul style="list-style-type: none"> <li>NONE</li> <li>MII</li> <li>GMII</li> </ul> | NONE            | <p>Specify whether to include an MII or GMII port to communicate with the fast C&amp;M (Ethernet) CPRI subchannel. You can also specify that the IP core does not support either interface.</p> <ul style="list-style-type: none"> <li>An MII port complies with the IEEE 802.3 100BASE-X 100Mbps MII specification,</li> <li>A GMII port complies with the IEEE 802.3 1000BASE-X 1Gbps GMII specification.</li> </ul> <p>For full Ethernet communication, you must connect a user-defined Ethernet MAC to this interface.</p>                          |
| <b>L2 Ethernet PCS Tx/Rx buffer depth</b>                                   | 7, 8, 9, 10, 11   | 7               | <p>The value you specify for this parameter is <math>\log_2</math> of the IP core Layer 2 Ethernet PCS Rx buffer depth and Tx buffer depth. The IP core supports a maximum Layer 2 Ethernet PCS buffer depth of 1024 for MII and 2048 for GMII.</p> <p>This parameter is available when you include an MII or GMII port to communicate with the fast C&amp;M (Ethernet) CPRI subchannel by selecting the value of <b>MII</b> or <b>GMII</b> for the <b>Ethernet PCS interface</b> parameter.</p> <p>The new value of 11 is supported only for GMII.</p> |
| <b>Debug Features</b>   |   |                 |   |

| Parameter   | Options   | Default Setting | Parameter Description   |
|---|---|-----------------|---|
| <b>Enable L1 debug interfaces</b>   | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to include dedicated transceiver status and L1 Rx status interfaces to support debug.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b>.</p>  |
| <b>Enable ADME, transceiver capability, control and status registers access</b> | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to support debugging through the System Console and to expose transceiver registers. If you turn off this parameter and also turn off <b>Enable line bit rate auto-negotiation</b>, <b>Enable start-up sequence state machine</b>, and <b>Enable single-trip delay calibration</b>, the Intel Arria 10 or Intel Stratix 10 transceiver reconfiguration interface is not available.</p> <p>This parameter is available only for Intel Arria 10 and Intel Stratix 10 devices.</p> |
| <b>Enable transceiver PMA serial forward loopback path</b>                      | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to enable transceiver PMA serial forward loopback. To turn on transceiver PMA serial forward loopback (Tx to Rx), you must also write the value of 2'b01 to the <code>loop_forward</code> field of the <code>LOOPBACK</code> register at offset 0x44.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b> or to <b>RX Simplex</b>.</p>  |
| <b>Enable parallel forward loopback paths</b>                                   | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to enable other internal parallel forward loopback paths (Tx to Rx). To turn on internal parallel forward loopback, you must also write a non-zero value to the <code>loop_forward</code> field of the <code>LOOPBACK</code> register at offset 0x44.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b> or to <b>RX Simplex</b>.</p>  |

| Parameter                                      | Options   | Default Setting | Parameter Description  |
|--|---|-----------------|--|
| <b>Enable parallel reversed loopback paths</b> | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to enable internal parallel reverse loopback (Rx to Tx). To turn on reverse loopback, you must also write a non-zero value to the <code>loop_reversed</code> field of the <code>LOOPBACK</code> register at offset 0x44, to specify the parts of the CPRI frame that are sent on the loopback path.</p> <p>This parameter is not available if you set the value of <b>Operation mode</b> to <b>TX Simplex</b> or to <b>RX Simplex</b>.</p> |

**Table 2-5: CPRI v6.0 IP Core Advanced Feature Parameters**

Describes the parameters for customizing the CPRI v6.0 IP core delay calibration features. These parameters appear on the **Advanced** tab in the CPRI v6.0 parameter editor.

| Parameter                                   | Options   | Default Setting | Parameter Description   |
|---|---|-----------------|---|
| <b>Enable single-trip delay calibration</b> | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to specify that your CPRI v6.0 IP core supports single-trip delay calibration.</p> <p>If you turn on this parameter, your IP core implements single-trip delay calibration only if you connect it according to <a href="#">Adding and Connecting the Single-Trip Delay Calibration Blocks</a> on page 2-23. Intel provides the required external blocks but you must connect them to the IP core in your design.</p> <p>This parameter is only available in IP core variations that target an Intel Arria 10 device.</p> <p>If you turn off this parameter and also turn off <b>Enable line bit rate auto-negotiation</b>, <b>Enable start-up sequence state machine</b> the transceiver reconfiguration interface is not available.</p> <p>This parameter is available only if you set the value of the <b>Core clock source input</b> parameter to <b>External</b>.</p> |
| <b>Enable round-trip delay calibration</b>  | <ul style="list-style-type: none"> <li>On</li> <li>Off</li> </ul> | Off             | <p>Turn on this parameter to to specify that your CPRI v6.0 IP core supports round-trip delay calibration.</p> <p>This parameter is available only if you set the value of the <b>Synchronization mode</b> parameter to <b>Master</b>.</p>  |

| Parameter                                      | Options   | Default Setting | Parameter Description  |
|--|---|-----------------|--|
| <b>Round-trip delay calibration FIFO depth</b> | <ul style="list-style-type: none"> <li>• 2</li> <li>• 3</li> <li>• 4</li> </ul> | 2               | <p>The value you specify for this parameter is <math>\log_2</math> of the IP core RTD calibration buffer depth. The IP core supports a maximum RTD calibration buffer depth of 16.</p> <p>The default depth of the buffer is 4, specified by the parameter default value of 2. For buffer depth <math>N</math>, the Read pointer can move <math>(N/2)-1</math> entries in either direction from its initial state.</p> |

**Related Information**

- [LOOPBACK Register](#) on page 5-15
- [CPRI v6.0 IP Core Clocking Structure](#) on page 3-3

## Integrating Your IP Core in Your Design: Required External Blocks

You must connect your CPRI v6.0 IP core to some additional required design components. Your design can simulate and compile without some of these connections and logical blocks, but it will not function correctly in hardware unless all of them are present and connected in your design.

The CPRI v6.0 IP core requires that you define, instantiate, and connect the following additional software and hardware modules for all CPRI v6.0 IP core variations:

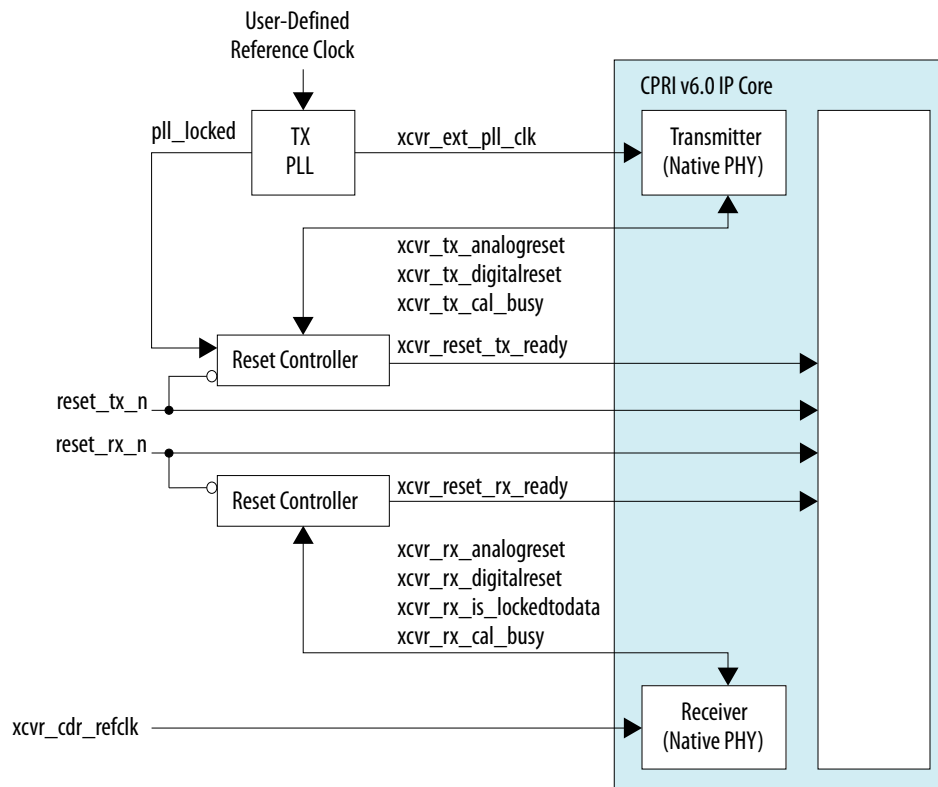
- An external PLL IP core to configure the transceiver TX PLL. Although the FPGA elements this IP core configures are physically part of the device transceiver, you must instantiate this IP core in software separately from the CPRI v6.0 IP core. In Intel Arria 10 and Intel Stratix 10 devices, this requirement supports the configuration of multiple Intel FPGA IP cores using the same transceiver block in the device.
- One or more external reset controllers to coordinate the reset sequence for the CPRI v6.0 IP core in your design.

In addition, some IP core variations require additional modules to function correctly in hardware.

- CPRI link slave modules require an off-chip clean-up PLL.
- Variations that target a 28-nm device (Arria V, Arria V GZ, Cyclone V, or Stratix V device family) require an external transceiver reconfiguration controller.
- Variations with the single-trip delay calibration feature require additional blocks that Intel provides but does not connect in your design.

**Figure 2-3: Required External Blocks**

An example showing how you could connect required components to a single CPRI v6.0 IP core that targets an Arria 10 device.



#### Related Information

[Adding the Reset Controller](#) on page 2-20

## Adding the Transceiver TX PLL IP Core

The CPRI v6.0 IP core requires that you generate and connect a TX transceiver PLL IP core. The transceiver PLL IP core configures the TX PLL in the transceiver on the device, but you must generate the transceiver PLL IP core separately from the CPRI v6.0 IP core in software. If you do not generate and connect the transceiver PLL IP core, the CPRI v6.0 IP core does not compile.

You can use the IP Catalog to generate the external PLL IP core that configures a TX PLL on the device. In the IP Catalog, select an Intel FPGA IP core that configures an appropriate PLL on your target device.

For your 28-nm design, you can select **Altera PLL (FPLL)** or **Transceiver PLL v17.0** in the IP Catalog. In the parameter editor for the TX PLL IP core you select, you must set the PLL output frequency to the expected input frequency for the CPRI v6.0 IP core `xcvr_ext_pll_clk` input signal.

For your Intel Arria 10 design, you can select **Arria 10 Transceiver ATX PLL**, **Arria 10 Transceiver CMU PLL**, or **Arria 10 FPLL** in the IP Catalog. For your Intel Stratix 10 design, you can select one of the

Transceiver PLL options available for your device tile type in the IP Catalog. In the parameter editor for the TX PLL IP core you select, you must set the following parameter values:

- **PLL output frequency** to one half the per-lane data rate of the IP core variation, multiplied by the value of the **Transmitter local clock division factor** parameter of the CPRI v6.0 IP core. The transceiver performs dual edge clocking, using both the rising and falling edges of the input clock from the PLL. Therefore, this PLL output frequency setting drives the transceiver with the correct clock for the CPRI v6.0 IP core line bit rate.

For example, if your CPRI v6.0 IP core variation has a CPRI line bit rate of 10.1376 Gbps and you set the **Transmitter local clock division factor** parameter to the value of 1, you must set the TX PLL **PLL output frequency** parameter to the value of 5068.8 MHz.

- **PLL reference clock frequency** to a frequency at which you can drive the TX PLL input reference clock. You must drive the external PLL reference clock input signal at the frequency you specify for this parameter.

For example, if your CPRI v6.0 IP core variation has a CPRI line bit rate of 10.1376 Gbps and you set the **Transmitter local clock division factor** parameter to the value of 1, you can set the **PLL reference clock frequency** to the value of 307.2 MHz.

Intel Arria 10 and Intel Stratix 10 devices and the Intel Quartus Prime software support multiple options for configuring an Intel Arria 10 TX PLL or Intel Stratix 10 TX PLL. Depending on the TX PLL IP core you select and the configuration options you prefer, you have a wide range of choices in parameterizing the external TX PLL for a design that targets one of these two device families.

You must connect the external TX PLL signals and the CPRI v6.0 IP core transceiver TX PLL interface signals according to the following rules.

**Table 2-6: Required Connections Between Transceiver TX PLL and CPRI v6.0 IP Core**

Connect the `xcvr_ext_pll_clk` input signal of the CPRI v6.0 IP core to the `pll_clkout`, `tx_serial_clk`, or `outclk0` output signal of the external PLL IP core. Information about connecting the transceiver TX PLL to the Reset Controller is available in [Adding the Reset Controller](#) on page 2-20.

| CPRI v6.0 IP Core Signal              | TX PLL Signal   |
|---------------------------------------|---|
| <code>xcvr_ext_pll_clk</code> (input) | Intel Arria 10 or Intel Stratix 10 CMU or ATX PLL: <code>tx_serial_clk</code> |
|                                       | Intel Arria 10 FPLL: <code>outclk0</code>                                     |
|                                       | 28-nm device CMU or ATX PLL: <code>pll_clkout</code>                          |
|                                       | 28-nm device FPLL: <code>outclk0</code>                                       |

If your CPRI v6.0 IP core is an RE slave, drive the input signal of the external PLL IP core with the output of the off-chip cleanup PLL.

User logic must provide the connections. Refer to the demonstration testbench for example working user logic including one correct method to instantiate and connect the external PLL to a single CPRI v6.0 IP core.

**Related Information**

- [Interface to the External PLL](#) on page 3-74

- **Altera Transceiver PHY IP Core User Guide**  
Information about how to configure an external PLL for your Arria V, Arria V GZ, Cyclone V, or Stratix V design.
- **Intel Arria 10 Transceiver PHY User Guide**  
Information about how to configure an external PLL for your own Intel Arria 10 design.
- **Intel Stratix 10 GX 2800 L-Tile ES-1 Transceiver PHY User Guide**  
Information about how to configure an external PLL for your Intel Stratix 10 design that targets an Intel Stratix 10 ES1 device.
- **Intel Stratix 10 L- and H-Tile Transceiver PHY User Guide**  
Information about how to configure an external PLL for your Intel Stratix 10 design that targets a production device.

## Adding the Reset Controller

The CPRI v6.0 IP core requires that you provide reset control logic to handle the required reset sequence for the IP core transceiver on the device. For a duplex CPRI v6.0 IP core, you must generate and connect two Transceiver PHY Reset Controller IP cores to perform this function, one reset controller for the TX transceiver and one reset controller for the RX transceiver in the CPRI v6.0 IP core. If you do not implement the device-specific correct reset sequence, the IP core does not function correctly in hardware.

You can use the IP Catalog to generate Transceiver PHY Reset Controller IP cores for the device family that your CPRI v6.0 IP core targets.

Follow the instructions in the *Altera Transceiver PHY IP Core User Guide*, the *Intel Arria 10 Transceiver PHY User Guide*, or the appropriate Stratix 10 transceiver PHY user guide. The CPRI v6.0 IP core configures the Native PHY IP core for the target device family. You must configure the reset controllers to coordinate reset of the CPRI v6.0 IP core including the Native PHY IP core, and the transceiver PLL IP core. In the case of Arria V, Arria V GZ, Cyclone V, and Stratix V variations, the reset controllers must also coordinate with the transceiver reconfiguration controller.

To configure a TX reset controller, in the Transceiver PHY Reset Controller parameter editor, you must set the following parameter values:

- Set **Input clock frequency** to a value in the range of 100–150 MHz. You must drive the CPRI v6.0 IP core `reconfig_clk` at the same frequency you specify for this parameter.
- Turn on **Synchronize reset input**.
- Turn on **Use fast reset for simulation**.
- Turn on **Enable TX PLL reset control**.
- Set **pll\_powerdown duration** to the value of 10.
- Turn on **Enable TX channel reset control**.
- Leave all other parameters turned off or for the parameters that do not turn on or off, at their default values.



To configure an RX reset controller, in the Transceiver PHY Reset Controller parameter editor, you must set the following parameter values:

- Set **Input clock frequency** to a value in the range of 100–150 MHz. You must drive the CPRI v6.0 IP core `reconfig_clk` at the same frequency you specify for this parameter.
- Turn on **Synchronize reset input**.
- Turn on **Use fast reset for simulation**.
- Turn on **Enable RX channel reset control**.
- Leave all other parameters turned off or for the parameters that do not turn on or off, at their default values.

You must connect the external reset controller signals to the CPRI v6.0 IP core reset controller interface signals and transceiver TX PLL signals according to the following rules. Refer to [Integrating Your IP Core in Your Design: Required External Blocks](#) on page 2-17 for an illustration of the connections.

**Table 2-7: Required Connections to and From Reset Controllers in CPRI v6.0 Design**

Lists the required connections between the reset controllers and the CPRI v6.0 IP core and the transceiver TX PLL IP core. For information about connecting the transceiver TX PLL to the CPRI v6.0 IP core, refer to [Adding the Transceiver TX PLL IP Core](#) on page 2-18.

| Transmit-Side Reset Controller Signal   | Connect to   |
|---|--|
| <code>clock</code> (input)              | Clock source for CPRI v6.0 IP core <code>reconfig_clk</code> input signal  |
| <code>reset</code> (input)              | Source of CPRI v6.0 IP core <code>reset_tx_n</code> input signal, inverted |
| <code>pll_powerdown</code> (output)     | TX PLL <code>pll_powerdown</code>  |
| <code>pll_locked</code> (input)         | TX PLL <code>pll_locked</code>   |
| <code>tx_analogreset</code> (output)    | CPRI v6.0 IP core <code>xcvr_tx_analogreset</code>                         |
| <code>tx_digitalreset</code> (output)   | CPRI v6.0 IP core <code>xcvr_tx_digitalreset</code>                        |
| <code>tx_cal_busy</code> (input)        | CPRI v6.0 IP core <code>xcvr_tx_cal_busy</code>                            |
| <code>tx_ready</code> (output)          | CPRI v6.0 IP core <code>xcvr_reset_tx_ready</code>                         |
| Receive-Side Reset Controller Signal    | Connect to   |
| <code>clock</code> (input)              | Clock source for CPRI v6.0 IP core <code>reconfig_clk</code> input signal  |
| <code>reset</code> (input)              | Source of CPRI v6.0 IP core <code>reset_rx_n</code> input signal, inverted |
| <code>rx_is_lockedtodata</code> (input) | CPRI v6.0 IP core <code>xcvr_rx_is_lockedtodata</code>                     |
| <code>rx_analogreset</code> (output)    | CPRI v6.0 IP core <code>xcvr_rx_analogreset</code>                         |
| <code>rx_digitalreset</code> (output)   | CPRI v6.0 IP core <code>xcvr_rx_digitalreset</code>                        |
| <code>rx_cal_busy</code> (input)        | CPRI v6.0 IP core <code>xcvr_rx_cal_busy</code>                            |
| <code>rx_ready</code> (output)          | CPRI v6.0 IP core <code>xcvr_reset_rx_ready</code>                         |

User logic must provide the connections. Refer to the demonstration testbench for example working user logic including one correct method to instantiate and connect the external reset controllers.

### Related Information

- [Interface to the External Reset Controller](#) on page 3-73
- [Integrating Your IP Core in Your Design: Required External Blocks](#) on page 2-17  
Figure illustrates the required connections.
- [Altera Transceiver PHY IP Core User Guide](#)  
Information about how to configure and connect the Altera Transceiver PHY Reset Controller for your Arria V, Arria V GZ, Cyclone V, or Stratix V design.
- [Intel Arria 10 Transceiver PHY User Guide](#)  
Information about how to configure and connect the Transceiver PHY Reset Controller for your Intel Arria 10 design.
- [Intel Stratix 10 GX 2800 L-Tile ES-1 Transceiver PHY User Guide](#)  
Information about how to configure and connect the Intel FPGA Transceiver PHY Reset Controller for your Stratix 10 design that targets a Intel Stratix 10 ES1 device.
- [Intel Stratix 10 L- and H-Tile Transceiver PHY User Guide](#)  
Information about how to configure and connect the Intel FPGA Transceiver PHY Reset Controller for your Intel Stratix 10 design that targets a production device.

## Adding the Transceiver Reconfiguration Controller

CPRI v6.0 IP cores that target Arria V, Arria V GZ, Cyclone V, and Stratix V devices require an external reconfiguration controller to compile and to function correctly in hardware. CPRI v6.0 IP cores that target Intel Arria 10 or Intel Stratix 10 devices include a transceiver reconfiguration controller block and do not require an external reconfiguration controller.

You can use the IP Catalog to generate the Altera Transceiver Reconfiguration Controller IP core.

When you configure the Altera Transceiver Reconfiguration Controller, you must specify the number of reconfiguration interfaces. The number of reconfiguration interfaces required for the CPRI v6.0 IP core depends on the CPRI v6.0 IP core configuration and your design. For example, you can configure your reconfiguration controller with additional interfaces if your design connects with multiple transceiver IP cores. You can leave other options at the default settings or modify them for your preference. Refer to the *Altera Transceiver PHY User Guide*.

You should connect the `reconfig_to_xcvr` and `reconfig_from_xcvr` ports of the CPRI v6.0 IP core to the corresponding ports of the reconfiguration controller.

You must drive the CPRI v6.0 IP core `reconfig_clk` input port and the Altera Transceiver Reconfiguration Controller `mgmt_clk_clk` input port from the same clock source. Drive both ports at a clock frequency in the range of 100–150MHz.

### Related Information

- [Arria V, Arria V GZ, Cyclone V, and Stratix V Transceiver Reconfiguration Interface](#) on page 3-70
- [Altera Transceiver PHY IP Core User Guide](#)  
For more information about the Altera Transceiver Reconfiguration Controller.

## Adding the Off-Chip Clean-Up PLL

If your CPRI v6.0 IP core is an RE slave, you must connect it to an off-chip clean-up PLL to clean up any jitter that occurs in the CDR output clock, before sending it to the reference clock input of the external TX PLL.

The clean-up PLL performs the clock synchronization necessary to address the CPRI v6.0 Specification requirements R-17, R-18, and R-18A, which address jitter and frequency accuracy in the RE core clock for radio transmission.

Drive the clean-up PLL with the CPRI v6.0 IP core `xcvr_recovered_clk` output clock, and connect the cleaned up output to the external TX PLL input reference clock port. In the internal clocking mode, in 8.11008 Gbps and 10.1376 Gbps IP core variations, you should connect the cleaned up output to the `cpri_coreclk` input clock port as well. In the external clocking mode, you can optionally connect the cleaned up output to the `cpri_coreclk` input clock port.

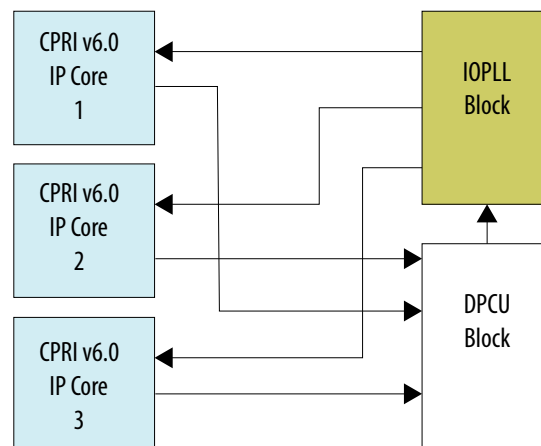
#### Related Information

[CPRI v6.0 IP Core Clocking Structure](#) on page 3-3

## Adding and Connecting the Single-Trip Delay Calibration Blocks

If you turn on **Enable single-trip delay calibration** in the CPRI v6.0 parameter editor, and **Synchronization mode** is set to **Slave**, the CPRI v6.0 IP core requires that you connect the IOPLL (`p11_core` block) and the Dynamic Phase Control Unit (DPCU) (`p11_dpcu` block). You must generate a device core PLL to create the IOPLL. Intel provides the DPCU block with the CPRI v6.0 IP core, but you must connect it, and the IOPLL, in your design. A single IOPLL block and a single DPCU block can connect to multiple CPRI v6.0 IP cores.

**Figure 2-4: Connecting a Single DPCU Block and Single IOPLL Block to Multiple CPRI v6.0 IP Cores**



You must generate a non-transceiver PLL IP core to create the IOPLL block. You can use the IP Catalog to generate the external PLL IP core that configures a core PLL on the device. In the IP Catalog, select an Intel FPGA IP core that configures an appropriate PLL on your target device.

For your Intel Arria 10 design, you must select **Arria 10 FPLL** in the IP Catalog. In the parameter editor for the fPLL IP core, you must set the following parameter values:

- Set **fPLL Mode** to **Core**.
- Set the PLL output frequency to the expected input frequency for the CPRI v6.0 IP core `cpri_coreclk` input signal.
- Turn on **Enable access to dynamic phase shift ports**.

You must connect the IOPLL and DPCU signals to the CPRI v6.0 IP core signals according to the following rules. Refer to [Example CPRI v6.0 Clock Connections in Different Clocking Modes](#) on page 3-8 for an illustration of the clock connections.

**Table 2-8: Required Connections to and From IOPLL Block in CPRI v6.0 Design With Single-Trip Delay Calibration**

| IOPLL Block Signal       | Connect to   |
|--------------------------|--|
| cntsel (input)           | DPCU p11_cntsel output signal  |
| num_phase_shifts (input) | DPCU p11_num_phase_shifts output signal  |
| outclk_0 (output)        | CPRI v6.0 IP core cpri_coreclk input clock signal                                  |
| phase_done (output)      | DPCU p11_phase_done input signal   |
| phase_en (input)         | DPCU p11_phase_en output signal  |
| refclk (input)           | CPRI v6.0 IP core tx_clkout output signal or output from the off-chip clean-up PLL |
| rst (input)              | Drive with the inverse of the CPRI v6.0 IP core reset_n input signal               |
| scanclk (input)          | DPCU p11_scanclk output signal   |
| updn (input)             | DPCU p11_updn output signal  |

**Table 2-9: Required Connections to and From DPCU Block in CPRI v6.0 Design With Single-Trip Delay Calibration**

| DPCU Block Signal | Connect to   |
|-------------------|--|
| clk               | Drive in the frequency range of 100–150 MHz.<br><b>Note:</b> Intel recommends that you drive this DPCU input clock with the source for the reconfig_clk. |
| reset_n (input)   | CPRI v6.0 IP core reset_n input signal   |

| DPCU Block Signal             | Connect to  |
|-------------------------------|---|
| csr_bit_rate (input)          | <p>If you turned on <b>Enable line bit rate auto-negotiation</b> in the CPRI v6.0 parameter editor, connect to the CPRI v6.0 IP core nego_bitrate_out[4:0] output signal.</p> <p>If autorate negotiation is not turned on, hardwire the DPCU csr_bit_rate signal to the encoded value for the CPRI line bit rate:</p> <ul style="list-style-type: none"> <li>• 5'b00001: 0.6144 Gbps</li> <li>• 5'b00010: 1.2288 Gbps</li> <li>• 5'b00100: 2.4576 Gbps</li> <li>• 5'b00101: 3.0720 Gbps</li> <li>• 5'b01000: 4.9150 Gbps</li> <li>• 5'b01010: 6.1440 Gbps</li> <li>• 5'b01100: 8.11008 Gbps</li> <li>• 5'b10000: 9.8304 Gbps</li> <li>• 5'b10100: 10.1376 Gbps</li> </ul> |
| cal_status (output)           | CPRI v6.0 IP core cal_status input signal   |
| cal_ctrl (input)              | CPRI v6.0 IP core cal_ctrl output signal  |
| pll_cntsel (output)           | IOPLL cntsel input signal   |
| pll_num_phase_shifts (output) | IOPLL num_phase_shifts input signal   |
| pll_phase_done (input)        | IOPLL phase_done output signal  |
| pll_phase_en (output)         | IOPLL phase_en input signal   |
| pll_scanclk (output)          | IOPLL scanclk input signal  |
| pll_updn (output)             | IOPLL updn input signal   |

User logic must provide the connections.

## Simulating Intel FPGA IP Cores

The Intel Quartus Prime software supports RTL- and gate-level design simulation of Intel FPGA IP cores in supported EDA simulators. Simulation involves setting up your simulator working environment, compiling simulation model libraries, and running your simulation.

You can use the functional simulation model and the testbench or example design generated with your IP core for simulation. The IP generation output also includes scripts to compile and run any testbench. For a complete list of models or libraries required to simulate your IP core, refer to the scripts generated with the testbench.

### Related Information

- [Simulating Intel FPGA IP Cores](#)

- [Simulating Altera FPGA Designs chapter in Quartus Prime Standard Edition Handbook, Volume 3: Verification](#)
- [Simulating Intel FPGA Designs chapter in Intel Quartus Prime Pro Edition Handbook, Volume 3: Verification](#)

## Understanding the Testbench

Intel provides a demonstration testbench with the CPRI v6.0 IP core.

If you click **Generate Example Design** in the CPRI v6.0 parameter editor, the Quartus Prime software generates the demonstration testbench. The parameter editor prompts you for the desired location of the testbench.

The testbench is static and does not necessarily match your IP core variation; you can generate it without generating an IP core. The testbench scripts generate a DUT that matches the testbench, but you must manually set the appropriate values for the DUT in the parameter editor before you create the demonstration testbench.

The testbench performs the following sequence of actions with the static DUT:

1. Enables transmission on the CPRI link by setting the `tx_enable` bit (bit [0]) of the CPRI v6.0 IP core `L1_CONFIG` register at offset 0x8 (and resetting all other fields of the register)>
2. Configures the DUT at the highest possible HDLC bit rate for the CPRI line bit rate, by setting the `tx_slow_cm_rate` field of the CPRI v6.0 `CM_CONFIG` register at offset 0x1C to the appropriate value.
3. Reads the `CM_CONFIG` register to confirm settings.
4. After the DUT and the testbench achieve frame synchronization, executes the following transactions:
  - a. Performs several write transactions to the AUX Tx interface and confirms the testbench receives them on the CPRI link.
  - b. Performs several write transactions to the VS interface and confirms the testbench receives them from the DUT on the CPRI link.
  - c. Performs several write transactions to the RTVS interface for the 10G variant, and confirms the testbench receives them from the DUT on the CPRI link.
  - d. Performs several write transactions to the Ctrl\_AxC interface and confirms the testbench receives them from the DUT on the CPRI link.
  - e. Performs several HDLC transactions for 1G and 2G and confirms the testbench receives them from the DUT on the CPRI link.
  - f. Performs several write transactions to the MI or GMI interface and confirms the testbench receives them from the DUT on the CPRI link.
  - g. Calculates the round-trip delay through the IP core.

## Running the Testbench

To run the CPRI v6.0 IP core demonstration testbench, follow these steps.

1. In the Quartus Prime software IP Catalog, select the CPRI v6.0 IP core and click **Add**.
2. When prompted, you can specify any output file type (HDL). This setting is relevant only for synthesis and does not impact simulation of the demonstration testbench.
3. In the CPRI v6.0 parameter editor, set the following parameter values:

**Table 2-10: CPRI v6.0 IP Core Variation for Demonstration Testbench**

The testbench scripts require that you set these values in the CPRI v6.0 parameter editor before you click **Generate Example Design**. The scripts generate the DUT but they require that you provide the parameter values.

| Parameter  | Value   |
|--|---|
| Line bit rate (Mbit/s)   | Any value the device family supports.   |
| Synchronization mode   | Master  |
| Operation mode   | TX/RX Duplex or RX Simplex  |
| Transmitter local clock division factor                                      | 1   |
| Number of receiver CDR reference clock(s)                                    | 1   |
| Receiver CDR reference clock frequency (MHz)                                 | 253.44 if the Line bit rate is 8.11008 Gbps and the IP core targets the Intel Arria 10 or Intel Stratix 10 device family<br>253.44 if the Line bit rate is 8.11008 or 10.1376 Gbps and the IP core targets a 28-nm device family<br>307.2 for all other cases |
| Core clock source input  | Internal  |
| Recovered clock source   | <b>PMA</b> if the Line bit rate is 10.1376 Gbps and IP core targets the Stratix V device family; <b>PCS</b> otherwise   |
| Receiver soft buffer depth (value shown is log <sub>2</sub> of actual depth) | 6   |
| Enable line bit rate auto-negotiation  | Turn off  |
| Enable line bit rate auto-negotiation down to 614.4 Mbps                     | Not available   |
| Management (CSR) interface standard  | AvalonMM  |
| Avalon-MM interface addressing type  | Word  |
| Auxiliary and direct interfaces write latency cycle(s)                       | 0   |
| Enable auxiliary interface   | <b>Turn on</b>  |
| Enable all control word access via management interface                      | Turn off  |
| Enable direct Z.130.0 alarm bits access interface                            | Turn off  |
| Enable direct ctrl_axc access interface                                      | <b>Turn on</b>  |
| Enable direct vendor specific access interface                               | <b>Turn on</b>  |
| Enable direct real-time vendor specific interface                            | Not available   |
| Enable start-up sequence state machine                                       | Turn off  |

| Parameter  | Value              |
|--|--------------------|
| Enable protocol version and C&M channel setting auto-negotiation         | Not available      |
| Enable direct IQ mapping interface                                       | Turn off           |
| Enable HDLC serial interface   | <b>Turn on</b>     |
| Ethernet PCS interface   | <b>MII or GMII</b> |
| L2 Ethernet PCS Tx/Rx FIFO depth (value shown is log2 of actual depth)   | 8                  |
| Enable L1 debug interfaces   | Turn off           |
| Enable ADME, transceiver capability, control and status registers access | Turn off           |
| Enable transceiver PMA serial forward loopback path                      | Turn off           |
| Enable parallel forward loopback paths                                   | Turn off           |
| Enable parallel reversed loopback paths                                  | Turn off           |
| Enable single-trip delay calibration                                     | Not available      |
| Enable round-trip delay calibration                                      | Turn off           |
| Round-trip delay calibration FIFO depth                                  | Not available      |

4. In the CPRI v6.0 parameter editor, click the **Generate Example Design** button and specify the desired location of the testbench.
5. After you generate the demonstration testbench, in the Quartus Prime software, click **View > Utility Windows > Tcl Console**.
6. In the Tcl Console, change directory to your specified testbench directory's `ip_sim` subdirectory.
7. Type `source gen_sim_verilog.tcl` or `source gen_sim_vhdl.tcl`, depending on the language of the model you wish to simulate. Running this script generates the DUT and testbench files.
8. If you are using a simulator that requires that you open a user interface, open your target simulator.
 

**Note:** You must select a simulator that is supported by the Intel Quartus Prime software version you are using.
9. Change directory to your specified testbench directory's `testbench/<simulator vendor>` subdirectory.
10. Execute the simulation script in the directory.
  - In the Mentor Graphics ModelSim simulator, type `do run_altera_cpri_v6_tb.tcl`
  - In the Synopsys VCS-MX simulator, type `sh run_altera_cpri_v6_vcsmx_tb.sh`
  - In the Cadence NCSIM simulator, type `sh run_altera_cpri_v6_tb.sh`

## Compiling the Full Design and Programming the FPGA

You can use the **Start Compilation** command on the Processing menu in the Intel Quartus Prime software to compile your design. After successfully compiling your design, program the targeted Intel FPGA with the Programmer and verify the design in hardware.



**Note:** The IP core directory includes a Synopsys Constraint (.sdc) file at <IP core instance directory>/altera\_cpri\_ii\_instance\_<Intel Quartus Prime release>/synth/altera\_cpri.sdc.

#### Related Information

- [Incremental Compilation for Hierarchical and Team-Based Design](#)
- [Programming Intel Devices](#)

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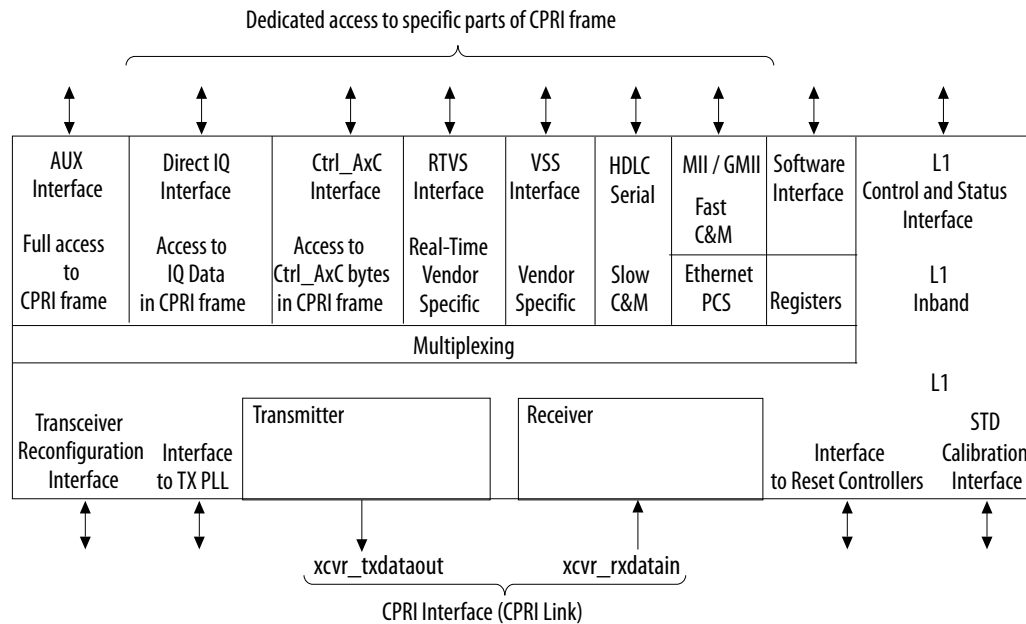
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The CPRI v6.0 IP core implements Layer 1 of the CPRI V6.0 specification and provides optional CPRI V6.0 Layer 2 access points through various interfaces.

## Interfaces Overview

Figure 3-1: CPRI v6.0 IP Core Interfaces

The IP core assembles the outbound CPRI frame control words and data from all of these interfaces, and unloads and routes control words and data from the inbound CPRI frame to the appropriate interfaces, based on configuration and register settings. With parameter settings, you control the presence or absence of the AUX interface, the L1 control and status interface, and each of the interfaces that provide dedicated access to specific parts of the CPRI frame. In contrast, the CPRI interface, the transceiver interfaces, and the software interface to the IP core registers are always implemented.



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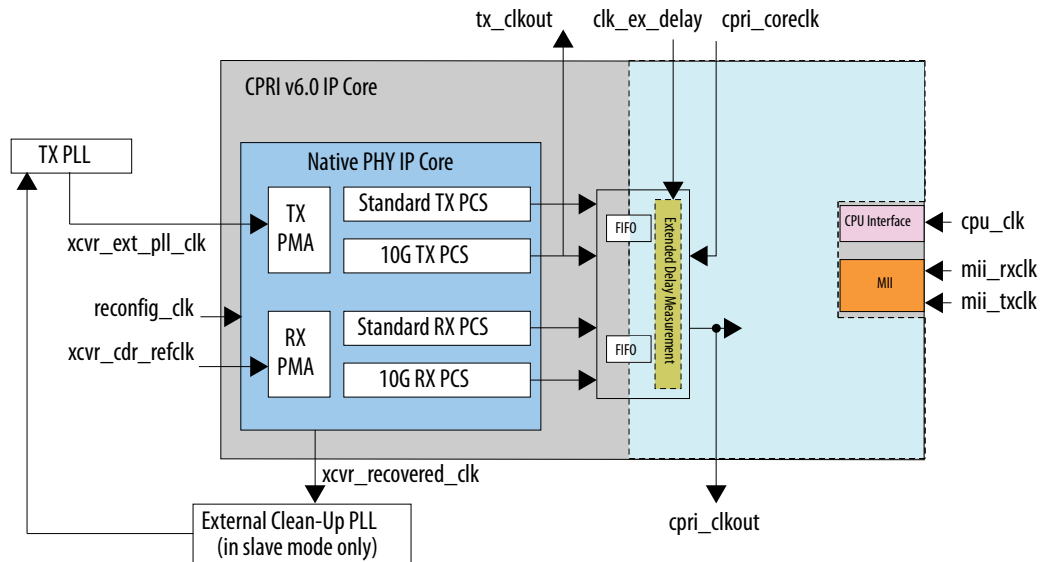
Multiple interfaces control the contents of the outbound CPRI frame control words and data. The CPRI v6.0 implements the following transmission priorities among these interfaces:

- CPRI frame control words:
  1. If the IP core implements the AUX interface, the AUX interface `aux_tx_data` bus, with appropriate delay, has first priority in filling in the outbound CPRI frame control words.
  2. If the IP core does not implement the AUX interface, or the `aux_tx_mask` value associated with the relevant incoming data blocks the relevant `aux_tx_data` bits, each of the following interfaces, if implemented, has secondary priority in filling the relevant part of the outbound CPRI frame control words:
    - Real-time vendor specific interface (RTVS)
    - Vendor specific interface (VS)
    - AxC control information interface (Ctrl\_AxC)
  3. For any part of the CPRI frame control words not filled in by one of the previous methods, the transmission-enabled values most recently written to the control transmit table through the full control word access registers `CTRL_INDEX` and `TX_CTRL` determine the contents of the outbound CPRI frame control words. If the most recently written word for a CPRI frame position is not transmission-enabled, no transmission is authorized from the control transmit table to that CPRI frame position.
  4. If none of the previous methods provides the content for a position in the CPRI frame control word, the following interfaces, if implemented, have the lowest priority in filling the relevant part of the outbound CPRI frame control words:
    - Fast control and management (Ethernet) MII or GMII interface
    - Slow control and management (HDLC) serial interface
    - L1 control and status interface
    - Dedicated registers that contain or control content for control word positions in the CPRI frame. For example, the `rx_prot_ver_filter` field of the `PROT_VER` register
    - Transmission of special symbols according to the CPRI protocol. For example, K28.5, D16.2, /S/, or /T/
- CPRI frame I/Q data words:
  1. If the IP core implements the AUX interface, the AUX interface `aux_tx_data` bus, with appropriate delay, has first priority in filling in the outbound CPRI frame I/Q data words.
  2. If the IP core does not implement the AUX interface, or the `aux_tx_mask` value associated with the relevant incoming data blocks the relevant `aux_tx_data` bits, the Direct I/Q interface, if implemented, has secondary priority in filling the relevant part of the outbound CPRI frame I/Q data words.

## CPRI v6.0 IP Core Clocking Structure

**Figure 3-2: CPRI v6.0 IP Core Clocking Structure**

Illustrates the clocks and clock domains in the CPRI v6.0 IP core. Clock domains shown are `cpri_clkout`, `clk_ex_delay`, `cpu_clk`, and `mii_{rx,tx}clk`. The external clean-up PLL is only required in slave clocking mode. The `tx_clkout` is only available in external clocking mode, and the `xcvr_recovered_clk` is only available in slave clocking mode.



The main CPRI v6.0 IP core clock is `cpri_clkout`.

**Table 3-1: CPRI v6.0 IP Core Input Clocks**

| CPRI v6.0 Input Clock         | Information  |
|-------------------------------|--|
| <code>xcvr_ext_pll_clk</code> | <p>Clocks the transmitter PMA.</p> <p>You should drive this input clock with the output of the external TX PLL. The frequency of this clock must be one half of the CPRI line bit rate, multiplied by the local clock division factor. You must configure a PLL IP core that is capable of driving the required frequency.</p> |

| CPRI v6.0 Input Clock                   | Information   |
|---|---|
| xcsr_cdr_refclk or xcsr_cdr_refclk[1:0] | <p>Receiver CDR reference clock. You must drive this clock at the frequency you specified for the <b>Receiver CDR reference clock frequency (MHz)</b> parameter in the CPRI v6.0 parameter editor.</p> <p>If you set the <b>Number of receiver CDR reference clock(s)</b> parameter in the CPRI v6.0 parameter editor to the value of <b>2</b>, this clock is two bits wide.</p> <p>In the case of a two-bit xcsr_cdr_refclk port, drive xcsr_cdr_refclk[0] with the reference clock for the initial CPRI line bit rate, because by default, this is the clock signal that drives the CDR.</p> <p>The IP core supports all CDR reference clock frequencies available in the drop-down menu for the <b>Receiver CDR reference clock frequency (MHz)</b> parameter.</p>   |
| reconfig_clk                            | <p>In Arria V, Arria V GZ, Cyclone V, and Stratix V variations, clock for CPRI v6.0 IP core transceiver start-up and reconfiguration.</p> <p>In Intel Arria 10 and Intel Stratix 10 variations, clocks the signals on the CPRI v6.0 transceiver reconfiguration interface. In these variations, this clock is not present if you turn off all of <b>Enable start-up sequence state machine</b>, <b>Enable ADME</b>, <b>transceiver capability, control and status registers access</b>, and parameters only available in Intel Arria 10 variations, <b>Enable line bit rate auto-negotiation</b>, <b>Enable single-trip delay calibration</b>.</p> <p>In variations that target any other supported device family, this clock is not present if you turn off both <b>Enable line bit rate auto-negotiation</b>, <b>Enable start-up sequence state machine</b>.</p> <p>The supported frequency range of this clock is 100–150 MHz.</p> |
| ex_delay_clk                            | Clock for extended delay measurement.   |
| latency_sclk                            | Clock for delay measurement through the Intel Stratix 10 hard FIFO buffers in the PCS and the core. You can (but need not) drive this clock at the same frequency as ex_delay_clk. This clock is present only in IP cores that target an Intel Stratix 10 device.   |

| CPRI v6.0 Input Clock                                      | Information   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
|--|---|--------------------|------------------------------------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|------------|-------------|------------|--------------|------------|-------------|------------|--------------|------------|
| <p><code>cpri_coreclk</code></p>                           | <p>In internal clocking mode, drives the CPRI v6.0 IP core clock <code>cpri_clkout</code> when the IP core is running at the CPRI line bit rate of 8.11008 Gbps or 10.1376 Gbps. In external clocking mode, drives <code>cpri_clkout</code> at all CPRI line bit rates.</p> <p>The frequency at which you must drive <code>cpri_coreclk</code> depends on the CPRI line bit rate:</p> <table border="1"> <thead> <tr> <th>CPRI Line Bit Rate</th> <th><code>cpri_clkout</code> Frequency</th> </tr> </thead> <tbody> <tr> <td>0.6144 Gbps</td> <td>15.36 MHz</td> </tr> <tr> <td>1.2288 Gbps</td> <td>30.72 MHz</td> </tr> <tr> <td>2.4576 Gbps</td> <td>61.44 MHz</td> </tr> <tr> <td>3.0720 Gbps</td> <td>76.80 MHz</td> </tr> <tr> <td>4.9152 Gbps</td> <td>122.88 MHz</td> </tr> <tr> <td>6.1440 Gbps</td> <td>153.60 MHz</td> </tr> <tr> <td>8.11008 Gbps</td> <td>245.76 MHz</td> </tr> <tr> <td>9.8304 Gbps</td> <td>245.76 MHz</td> </tr> <tr> <td>10.1376 Gbps</td> <td>307.20 MHz</td> </tr> </tbody> </table> <p>You must drive this clock from the same clock source as the <code>xcvr_ext_pll_clk</code> input signal to the IP core.</p> | CPRI Line Bit Rate | <code>cpri_clkout</code> Frequency | 0.6144 Gbps | 15.36 MHz | 1.2288 Gbps | 30.72 MHz | 2.4576 Gbps | 61.44 MHz | 3.0720 Gbps | 76.80 MHz | 4.9152 Gbps | 122.88 MHz | 6.1440 Gbps | 153.60 MHz | 8.11008 Gbps | 245.76 MHz | 9.8304 Gbps | 245.76 MHz | 10.1376 Gbps | 307.20 MHz |
| CPRI Line Bit Rate   | <code>cpri_clkout</code> Frequency  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 0.6144 Gbps  | 15.36 MHz   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 1.2288 Gbps  | 30.72 MHz   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 2.4576 Gbps  | 61.44 MHz   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 3.0720 Gbps  | 76.80 MHz   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 4.9152 Gbps  | 122.88 MHz  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 6.1440 Gbps  | 153.60 MHz  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 8.11008 Gbps   | 245.76 MHz  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 9.8304 Gbps  | 245.76 MHz  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 10.1376 Gbps   | 307.20 MHz  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| <p><code>cpu_clk</code></p>                                | <p>Clocks the signals on the CPRI v6.0 CPU interface. Supports any frequency that the device fabric supports.</p>   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| <p><code>mii_txclk</code><br/><code>mii_rxclk</code></p>   | <p><code>mii_txclk</code> clocks the MII transmitter interface and <code>mii_rxclk</code> clocks the MII receiver interface. You must drive these clocks at the frequency of 25 MHz/2.5 MHz to achieve the 100 Mbps/10 Mbps bandwidth required for this interface.</p> <p>These clocks are present only if you set the value of <b>Ethernet PCS interface</b> to the value of <b>MII</b> in the CPRI v6.0 parameter editor.</p>   |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| <p><code>gmii_txclk</code><br/><code>gmii_rxclk</code></p> | <p><code>gmii_txclk</code> clocks the GMII transmitter interface and <code>gmii_rxclk</code> clocks the GMII receiver interface. You must drive these clocks at the frequency of 125 MHz to achieve the 1000 Mbps bandwidth required for this interface.</p> <p>These clocks are present only if you set the value of <b>Ethernet PCS interface</b> to the value of <b>GMII</b> in the CPRI v6.0 parameter editor.</p>  |                    |                                    |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |

Table 3-2: CPRI v6.0 IP Core Output Clocks

| CPRI v6.0 Output Clock | Information  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
|------------------------|--|--------------------|-----------------------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|------------|-------------|------------|--------------|------------|-------------|------------|--------------|------------|
| cpri_clkout            | <p>Master clock for the CPRI v6.0 IP core. In internal clocking mode, when the IP core is running at the CPRI line bit rate of 8.11008 Gbps or 10.1376 Gbps, the cpri_coreclk input clock drives cpri_clkout. At all other CPRI line bit rates, the Tx PCS drives cpri_clkout. In external clocking mode, the cpri_coreclk input clock drives cpri_clkout at all CPRI line bit rates.</p> <p>The frequency of cpri_clkout depends on the CPRI line bit rate:</p> <table border="1"> <thead> <tr> <th>CPRI Line Bit Rate</th> <th>cpri_clkout Frequency</th> </tr> </thead> <tbody> <tr> <td>0.6144 Gbps</td> <td>15.36 MHz</td> </tr> <tr> <td>1.2288 Gbps</td> <td>30.72 MHz</td> </tr> <tr> <td>2.4576 Gbps</td> <td>61.44 MHz</td> </tr> <tr> <td>3.0720 Gbps</td> <td>76.80 MHz</td> </tr> <tr> <td>4.9152 Gbps</td> <td>122.88 MHz</td> </tr> <tr> <td>6.1440 Gbps</td> <td>153.60 MHz</td> </tr> <tr> <td>8.11008 Gbps</td> <td>245.76 MHz</td> </tr> <tr> <td>9.8304 Gbps</td> <td>245.76 MHz</td> </tr> <tr> <td>10.1376 Gbps</td> <td>307.20 MHz</td> </tr> </tbody> </table> | CPRI Line Bit Rate | cpri_clkout Frequency | 0.6144 Gbps | 15.36 MHz | 1.2288 Gbps | 30.72 MHz | 2.4576 Gbps | 61.44 MHz | 3.0720 Gbps | 76.80 MHz | 4.9152 Gbps | 122.88 MHz | 6.1440 Gbps | 153.60 MHz | 8.11008 Gbps | 245.76 MHz | 9.8304 Gbps | 245.76 MHz | 10.1376 Gbps | 307.20 MHz |
| CPRI Line Bit Rate     | cpri_clkout Frequency  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 0.6144 Gbps            | 15.36 MHz  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 1.2288 Gbps            | 30.72 MHz  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 2.4576 Gbps            | 61.44 MHz  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 3.0720 Gbps            | 76.80 MHz  |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 4.9152 Gbps            | 122.88 MHz   |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 6.1440 Gbps            | 153.60 MHz   |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 8.11008 Gbps           | 245.76 MHz   |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 9.8304 Gbps            | 245.76 MHz   |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 10.1376 Gbps           | 307.20 MHz   |                    |                       |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |

| CPRI v6.0 Output Clock    | Information   |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
|---------------------------|---|--------------------|------------------------------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|------------|-------------|------------|--------------|------------|-------------|------------|--------------|------------|
| <p>xcvr_recovered_clk</p> | <p>Direct recovered clock from the receiver CDR. Use this output clock to drive the external clean-up PLL when your IP core is in slave mode.</p> <p>The IP core drives this clock from the PCS or the PMA block of the transceiver, depending on the value you set for the <b>Recovered clock source</b> parameter in the CPRI v6.0 parameter editor.</p> <p>This clock is present only in CPRI v6.0 IP cores in slave clocking mode that support RX traffic. (This clock is not present in CPRI v6.0 IP cores with <b>Operation mode</b> set to the value of <b>TX simplex</b>).</p> <p>The frequency of xcvr_recovered_clk depends on the CPRI line bit rate:</p> <table border="1"> <thead> <tr> <th>CPRI Line Bit Rate</th> <th>xcvr_recovered_clk Frequency</th> </tr> </thead> <tbody> <tr> <td>0.6144 Gbps</td> <td>15.36 MHz</td> </tr> <tr> <td>1.2288 Gbps</td> <td>30.72 MHz</td> </tr> <tr> <td>2.4576 Gbps</td> <td>61.44 MHz</td> </tr> <tr> <td>3.0720 Gbps</td> <td>76.80 MHz</td> </tr> <tr> <td>4.9152 Gbps</td> <td>122.88 MHz</td> </tr> <tr> <td>6.1440 Gbps</td> <td>153.60 MHz</td> </tr> <tr> <td>8.11008 Gbps</td> <td>220.75 MHz</td> </tr> <tr> <td>9.8304 Gbps</td> <td>245.76 MHz</td> </tr> <tr> <td>10.1376 Gbps</td> <td>253.44 MHz</td> </tr> </tbody> </table> | CPRI Line Bit Rate | xcvr_recovered_clk Frequency | 0.6144 Gbps | 15.36 MHz | 1.2288 Gbps | 30.72 MHz | 2.4576 Gbps | 61.44 MHz | 3.0720 Gbps | 76.80 MHz | 4.9152 Gbps | 122.88 MHz | 6.1440 Gbps | 153.60 MHz | 8.11008 Gbps | 220.75 MHz | 9.8304 Gbps | 245.76 MHz | 10.1376 Gbps | 253.44 MHz |
| CPRI Line Bit Rate        | xcvr_recovered_clk Frequency  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 0.6144 Gbps               | 15.36 MHz   |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 1.2288 Gbps               | 30.72 MHz   |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 2.4576 Gbps               | 61.44 MHz   |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 3.0720 Gbps               | 76.80 MHz   |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 4.9152 Gbps               | 122.88 MHz  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 6.1440 Gbps               | 153.60 MHz  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 8.11008 Gbps              | 220.75 MHz  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 9.8304 Gbps               | 245.76 MHz  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| 10.1376 Gbps              | 253.44 MHz  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |
| <p>tx_clkout</p>          | <p>TX PCS clock. In external clocking mode, you can use this clock to drive the cpri_coreclk input clock. If your IP core is configured with the single-trip delay calibration feature, you can use this clock to drive the IOPLL block.</p>  |                    |                              |             |           |             |           |             |           |             |           |             |            |             |            |              |            |             |            |              |            |

**Related Information**

[Adding the Off-Chip Clean-Up PLL](#) on page 2-22



## Example CPRI v6.0 Clock Connections in Different Clocking Modes

Figure 3-3: CPRI v6.0 Slave IP Core in Internal Clocking Mode

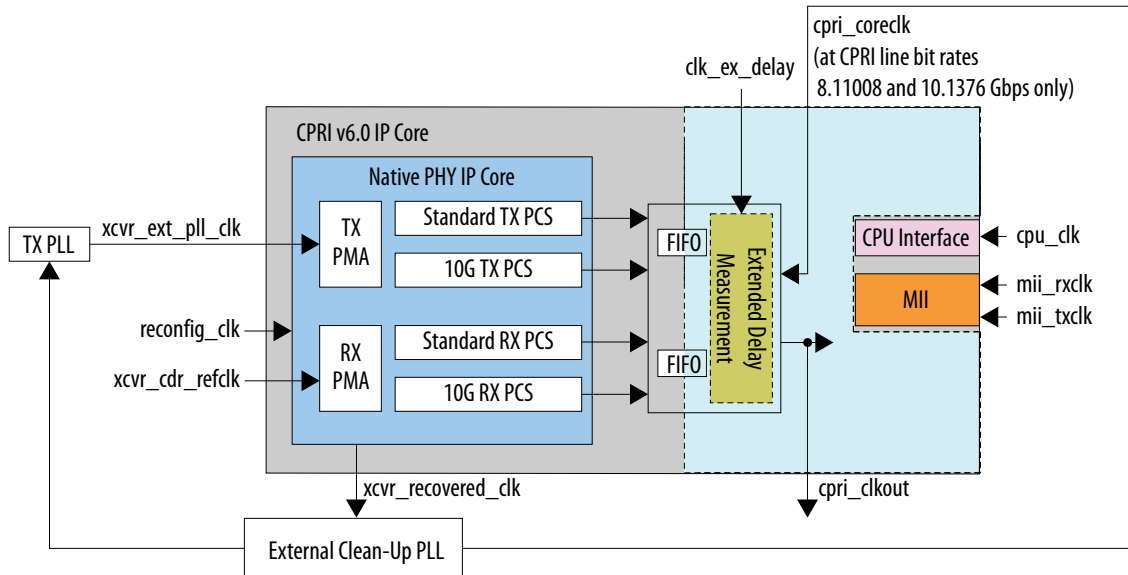


Figure 3-4: CPRI v6.0 Master IP Core in Internal Clocking Mode

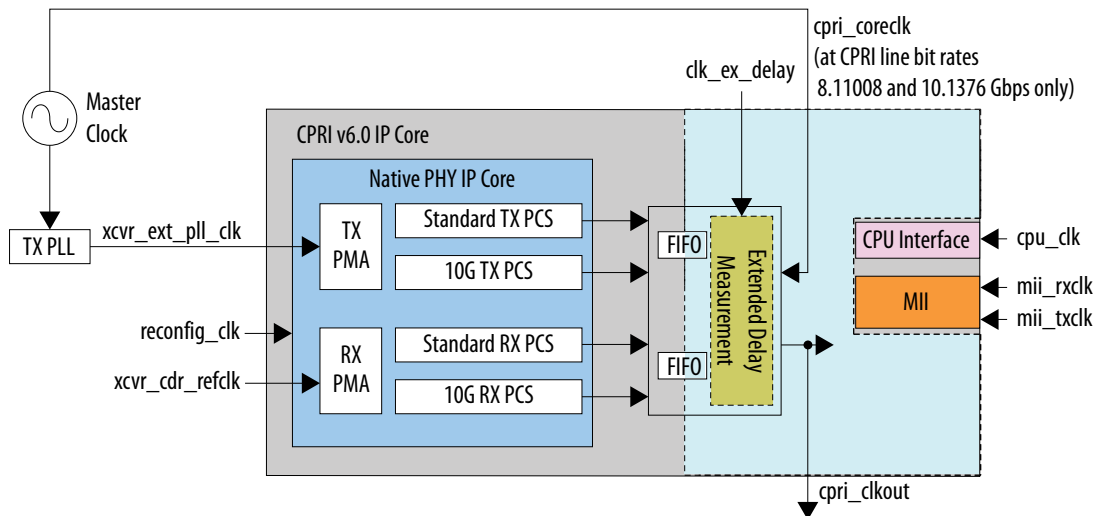


Figure 3-5: CPRI v6.0 Slave IP Core in External Clocking Mode

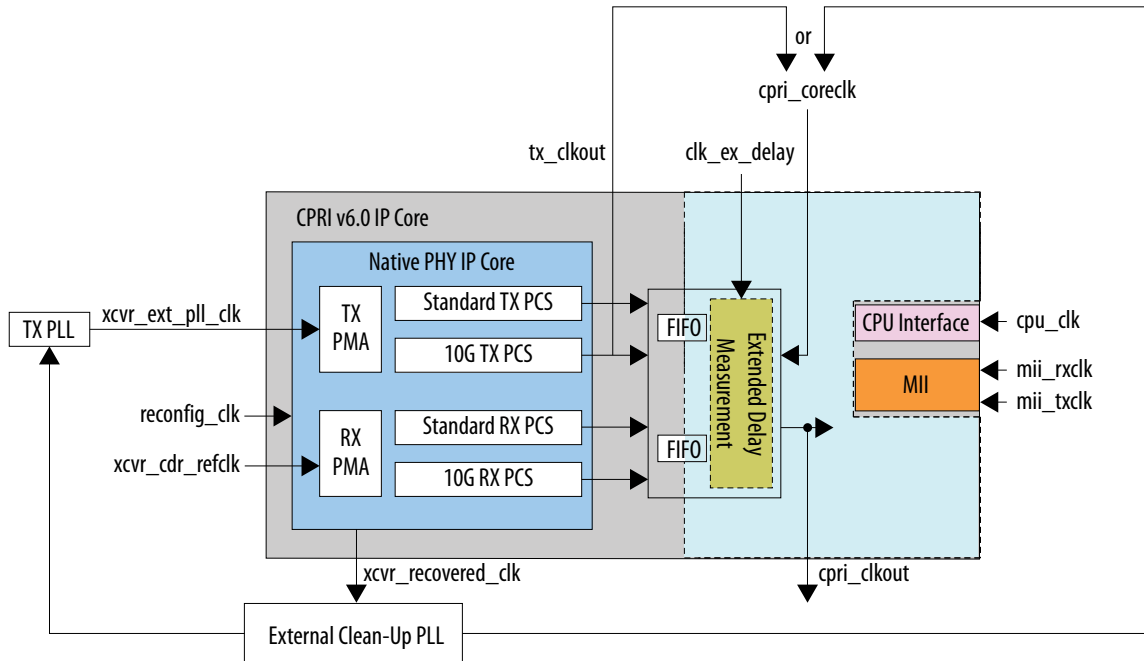
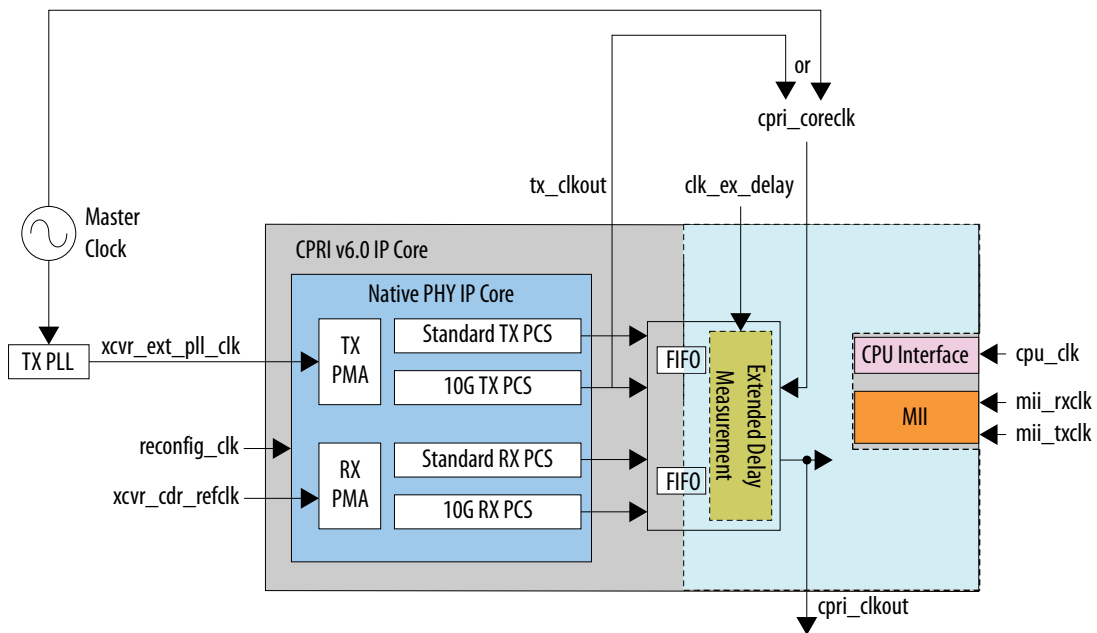
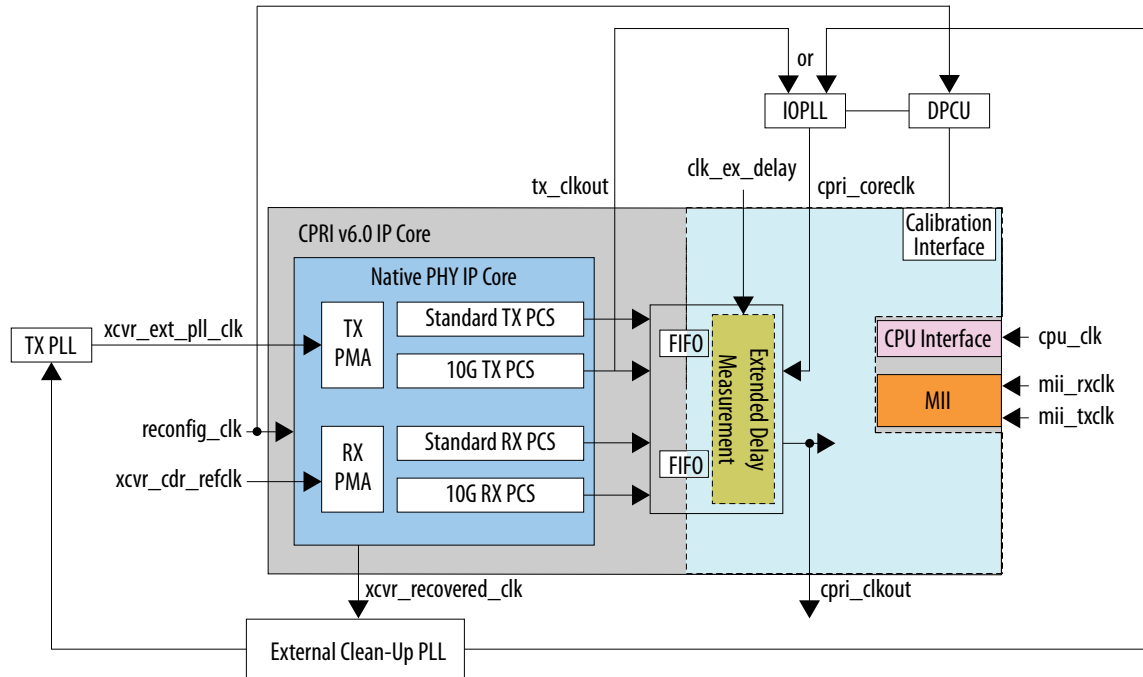


Figure 3-6: CPRI v6.0 Master IP Core in External Clocking Mode



**Figure 3-7: CPRI v6.0 Slave IP Core in External Clocking Mode with Single-Trip Delay Calibration Feature**

Intel provides the IOPLL and DPCU blocks with the CPRI v6.0 IP core. For correct single-trip delay calibration functionality, you must connect these blocks as shown.



## CPRI v6.0 IP Core Reset Requirements

To reset the entire CPRI v6.0 IP core, you must assert the reset signals to the IP core and to the required external reset controller logic. The external reset controller logic resets only the transceiver. If you instantiate a duplex CPRI v6.0 IP core, you must instantiate two PHY Reset Controllers to implement this logic, one for the TX data path and one for the RX data path. The two reset signals `reset_tx_n` and `reset_rx_n` each cause the reset logic to reset the relevant data path of the IP core. If you connect these two reset signals to the corresponding PHY Reset Controllers, each one also causes the transceiver in that data path to reset.

In the case of a duplex CPRI v6.0 IP core, you can assert the `reset_n` signal instead of asserting the two reset signals `reset_tx_n` and `reset_rx_n`. However, unless you also connect the `reset_n` signal to the external reset controllers, the transceivers do not reset in this case.

In addition, some individual interfaces to the IP core have their own reset signals to reset only the associated interface and logic.

**Table 3-3: CPRI v6.0 IP Core Reset Signals**

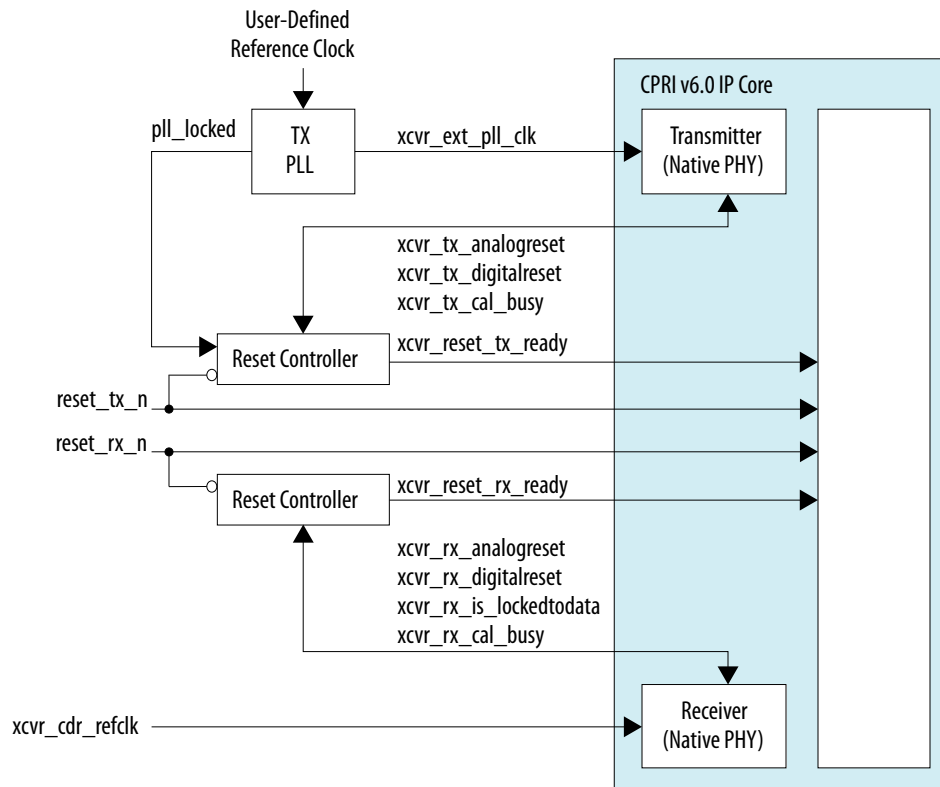
You can assert all reset signals asynchronously to any clock. However, you must hold each reset signal asserted for one full clock period of its associated clock, to ensure it is captured by the IP core.

| CPRI v6.0 IP Core Reset Signal | Polarity    | Associated Clock | Information   |
|--------------------------------|-------------|------------------|---|
| xcvr_tx_analogreset            | Active high | —                | Analog reset to transmitter from external reset controller.   |
| xcvr_tx_digitalreset           | Active high | —                | Digital reset to transmitter from external reset controller.  |
| xcvr_rx_analogreset            | Active high | —                | Analog reset to receiver from external reset controller.  |
| xcvr_rx_digitalreset           | Active high | —                | Digital reset to receiver from external reset controller.   |
| reset_n                        | Active low  | reconfig_clk     | Asynchronous global reset signal. Resets the IP core soft logic. This signal does not reset the CSR registers, the extended delay measurement settings, or the transceivers.<br><br>To reset the CSR registers, you must assert the <code>cpu_reset_n</code> signal. To reset the extended delay measurement settings, you must assert the <code>ex_delay_reset_n</code> signal.<br><br>To reset the transceiver you must drive the reset input port of the required PHY Reset Controllers. |
| reset_tx_n                     | Active low  | reconfig_clk     | Asynchronous global reset signal that resets the TX path of the CPRI v6.0 IP core. Resets the IP core soft logic. To reset the transceiver you must drive the reset input port of the required PHY Reset Controller.  |
| reset_rx_n                     | Active low  | reconfig_clk     | Asynchronous global reset signal that resets the RX path of the CPRI v6.0 IP core. Resets the IP core soft logic. To reset the transceiver you must drive the reset input port of the required PHY Reset Controller.  |
| ex_delay_reset_n               | Active low  | ex_delay_clk     | Resets the extended delay measurement block.  |
| latency_sreset_n               | Active low  | latency_sclk     | Resets the Intel Stratix 10 hard FIFO delay measurement soft logic.   |

| CPRI v6.0 IP Core Reset Signal | Polarity    | Associated Clock | Information  |
|--------------------------------|-------------|------------------|--|
| reconfig_reset                 | Active high | reconfig_clk     | <p>Asynchronous reset signal. Resets the CPRI v6.0 Intel Arria 10 or Intel Stratix 10 transceiver reconfiguration interface and all of the registers to which it provides access.</p> <p>In IP cores that target a 28-nm device, this signal is involved in rate switching and auto-rate negotiation.</p> <p>In Intel Arria 10 and Intel Stratix 10 variations, this signal is not present if you turn off all of <b>Enable start-up sequence state machine</b>, <b>Enable ADME</b>, <b>transceiver capability, control and status registers access</b>, and parameters only available in Intel Arria 10 variations, <b>Enable line bit rate auto-negotiation</b>, <b>Enable single-trip delay calibration</b>.</p> <p>In variations that target other devices, this signal is not present if you turn off all of <b>Enable line bit rate auto-negotiation</b>, <b>Enable start-up sequence state machine</b>.</p> |
| cpu_reset_n                    | Active low  | cpu_clk          | Resets the CPRI v6.0 CPU interface and all of the registers to which it provides access.   |
| mii_txreset_n                  | Active low  | mii_txclk        | Resets the MII transmitter interface and FIFO write logic.   |
| mii_rxreset_n                  | Active low  | mii_rxclk        | Resets the MII receiver interface and FIFO read logic.   |
| gmii_txreset_n                 | Active low  | gmii_txclk       | Resets the GMII transmitter interface and FIFO write logic.  |
| gmii_rxreset_n                 | Active low  | gmii_rxclk       | Resets the GMII receiver interface and FIFO read logic.  |

**Figure 3-8: Required External Blocks**

An example showing how you could connect required components to a single CPRI v6.0 IP core that targets an Arria 10 device.



To reset the CPRI v6.0 IP core, you must assert the active low `reset_tx_n`, `reset_rx_n`, `reset_tx_n` and `reset_rx_n`, or `reset_n` signals, as appropriate.

To reset the transceiver, you must trigger the reset controller logic. If you make the optional connection to drive the `reset_rx_n` or `reset_n` port from the same source as the reset signal for the RX side Reset Controller, asserting the active low `reset_rx_n` or `reset_n` signal also triggers the reset controller logic. If you make the optional connection to drive the `reset_tx_n` or `reset_n` port from the same source as the reset signal for the TX side Reset Controller, asserting the active low `reset_tx_n` or `reset_n` signal also triggers the TX reset controller logic.

When you trigger the reset controllers, they should deassert the `xcvr_reset_tx_ready` and `xcvr_reset_rx_ready` input ready signals to the IP core. After each reset controller completes resetting the transceiver and IP core data path, it should assert the relevant ready signal.

**Related Information**

[Integrating Your IP Core in Your Design: Required External Blocks](#) on page 2-17

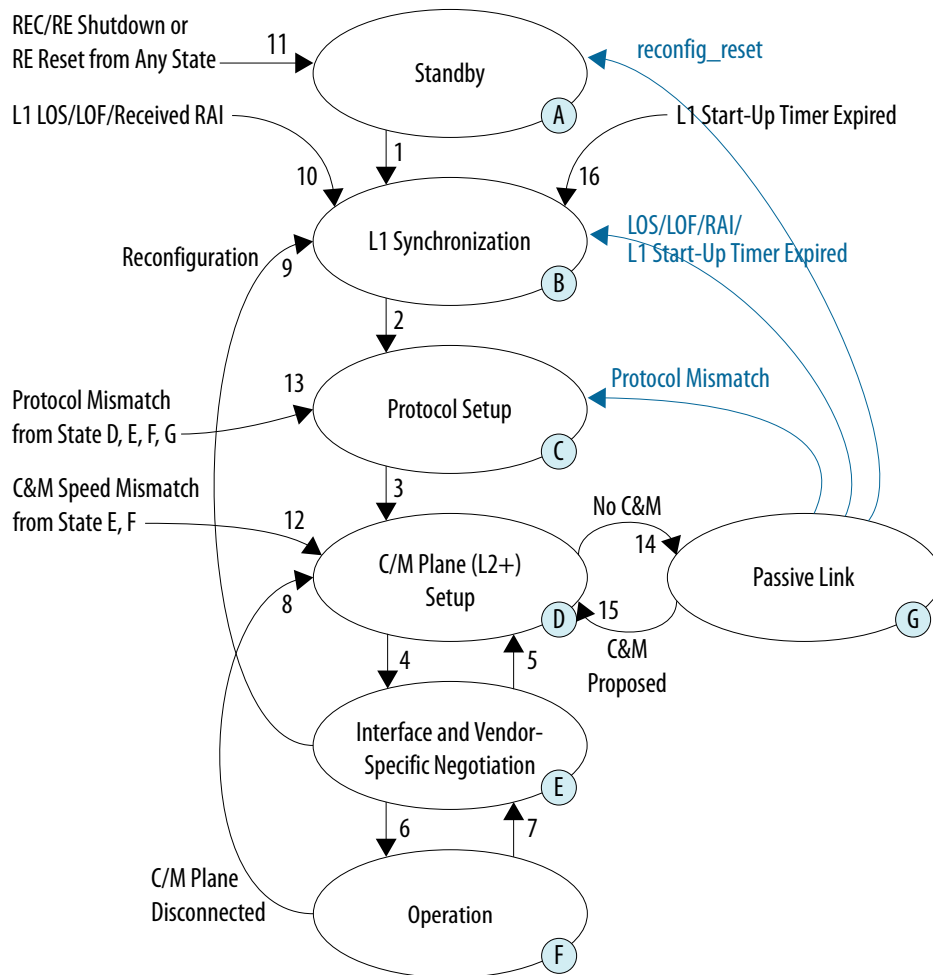
Shows main data path reset signals and how the reset controller connects to the IP core.

## Start-Up Sequence Following Reset

After reset, if you turned on **Enable start-up sequence state machine** in the CPRI v6.0 IP core, the internal state machine performs link synchronization and other initialization tasks. If you did not turn on **Enable start-up sequence state machine**, user logic should perform these functions.

**Figure 3-9: Start-up states and transitions** Figure From CPRI v6.1 Specification With IP Core Additions

States and transitions marked in black are from the CPRI v6.1 specification Figure 30: Start-up states and transitions. Additional transitions from State G that the IP core implements are marked in blue.



The internal state machine implements the start-up state machine transitions shown in section 4.5.2, Figure 30: Start-up states and transitions, and described in section 4.5.3, in the CPRI specification. In addition, the internal state machine implements the following transitions from State G: Passive Link.

- If you assert `reconfig_reset`, the start-up state machine transitions to State A.
- If the IP core detects any of the following situations, the start-up state machine transitions to State B:
  - **Loss of signal (LOS)**. Refer to *Direct L1 Control and Status Interface* and *FLSAR Register*.
  - **Loss of frame (LOF)**. Refer to *Direct L1 Control and Status Interface* and *FLSAR Register*.
  - **Remote alarm indication (RAI)**. Refer to *Direct L1 Control and Status Interface* and *FLSAR Register*.
  - **L1 start-up timer expiration**. If you turn on **Enable start-up sequence state machine** option, the IP core responds to both the `nego_l1_timer_expired` port and `startup_timer_expired` field of the `START_UP_SEQ` register at offset 0x24.
- If the IP core detects that protocol negotiation is not complete, the start-up state machine transitions to State C. The IP core detects that protocol negotiation is not complete if all of the following conditions hold:
  - `nego_protocol_complete` signal has the value of 0, and
  - `nego_protocol_complete` field of the `START_UP_SEQ` register at offset 0x24 has the value of 0, and
  - Slave protocol version does not match the protocol version of the CPRI master. Specifically, the `rx_prot_ver` and `tx_prot_ver` fields of the `PROT_VER` register at offset 0x10 have different values. When you turn on **Enable protocol version and C&M channel setting auto-negotiation** option, the IP core allows deframer to detect the incoming protocol version to the `csr_rx_prot_ver`, and compare it to the proposed `tx_prot_ver`. Then IP core detects that the protocol negotiation is complete.
- If the IP core detects that control and management negotiation is complete, the start-up state machine transitions to State D. The IP core detects that control and management negotiation is not yet complete if all of the following conditions hold:
  - `nego_cm_complete` signal has the value of 0, and
  - `nego_cm_complete` field of the `START_UP_SEQ` register at offset 0x24 has the value of 0, and
  - `rx_slow_cm_rate_valid` field of the `CM_STATUS` register has the value of 0, and
  - `rx_fast_cm_ptr_valid` field of the `CM_STATUS` register has the value of 0.

#### Related Information

- [Direct L1 Control and Status Interface](#) on page 3-40
- [FLSAR Register](#) on page 5-11

## Start-Up Sequence Interface Signals

After reset, if you turned on **Enable start-up sequence state machine** in the CPRI v6.0 IP core, the internal state machine performs link synchronization and other initialization tasks. If you did not turn on **Enable start-up sequence state machine**, user logic must perform these functions.

The signals visible in the interface depend on whether or not you turned on **Enable start-up sequence state machine**.

**Table 3-4: Start-Up Sequence Interface Signals**

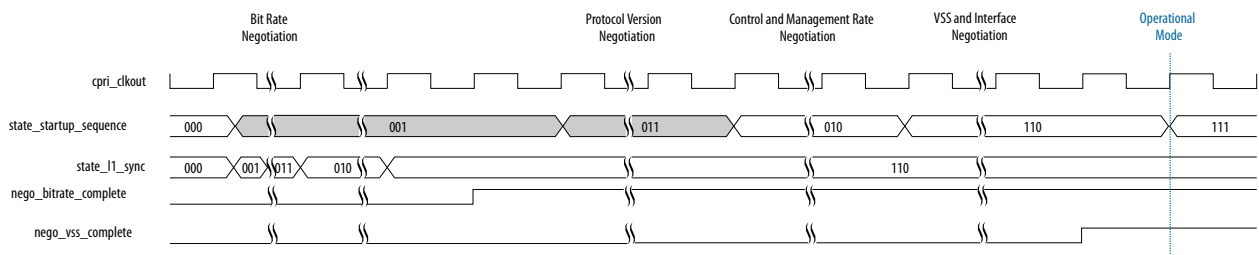
All interface signals are clocked by the `cpri_clkout` clock.



| Signal Name            | Direction | Description  |
|------------------------|-----------|--|
| state_startup_seq[2:0] | Output    | <p>Indicates the state of the CPRI start-up sequence state machine. This signal has the following valid values:</p> <ul style="list-style-type: none"> <li>3'b000: State A: Standby</li> <li>3'b001: State B: L1 Synchronization</li> <li>3'b011: State C: Protocol Setup</li> <li>3'b010: State D: Control and Management Setup</li> <li>3'b110: State E: Interface and VSS Negotiation</li> <li>3'b111: State F: Operation</li> <li>3'b101: State G: Passive Link</li> </ul> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p>  |
| state_l1_synch[2:0]    | Output    | <p>State B condition indicator. Indicates the state of the CPRI receiver L1 synchronization state machine. This signal has the following valid values:</p> <ul style="list-style-type: none"> <li>3'b000: XACQ1</li> <li>3'b001: XACQ2</li> <li>3'b011: XSYNC1</li> <li>3'b010: XSYNC2</li> <li>3'b110: HFNSYNC</li> </ul>   |
| nego_bitrate_complete  | Input     | <p>Indicates the CPRI line bit rate negotiation is complete. Input from external CPRI line bit rate negotiation block.</p> <p>If you do not turn on <b>Enable line bit rate auto-negotiation</b> in the CPRI v6.0 parameter editor, you should tie this signal high.</p> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p> <p>Asserting this signal advances the start-up sequence state machine from state B to state C. The IP core writes the value of this signal to the <code>nego_bitrate_complete</code> field of the <code>START_UP_SEQ</code> register at offset 0x24.</p> |
| nego_protocol_complete | Input     | <p>Indicates the CPRI protocol version negotiation is complete.</p> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p> <p>Asserting this signal advances the start-up sequence state machine from state C to state D. The IP core writes the value of this signal to the <code>nego_protocol_complete</code> field of the <code>START_UP_SEQ</code> register at offset 0x24.</p>   |

| Signal Name           | Direction | Description   |
|-----------------------|-----------|---|
| nego_cm_complete      | Input     | <p>Indicates the Control and Management negotiation is complete.</p> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p> <p>Asserting this signal advances the start-up sequence state machine from state D to state E. The IP core writes the value of this signal to the <code>nego_cm_complete</code> field of the <code>START_UP_SEQ</code> register at offset 0x24.</p>   |
| nego_vss_complete     | Input     | <p>Indicates the Vendor Specific negotiation is complete.</p> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p> <p>Asserting this signal advances the start-up sequence state machine from state E to state F. The IP core writes the value of this signal to the <code>nego_vss_complete</code> field of the <code>START_UP_SEQ</code> register at offset 0x24.</p>   |
| nego_l1_timer_expired | Input     | <p>If you do not turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> in the CPRI v6.0 parameter editor, drive this signal from your user-defined L1 timer to indicate that the L1 timer has expired.</p> <p>Note that if you do not turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b>, user logic is expected to maintain an L1 timer outside the IP core.</p> <p>This signal is available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor.</p> <p>If you also turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> in the CPRI v6.0 parameter editor, you should tie this signal low so it does not interfere with the internal L1 timer.</p> |

Figure 3-10: Start-Up Sequence State Machine Timing Diagram



## AUX Interface

The CPRI v6.0 IP core auxiliary (AUX) interface provides direct access to the CPRI 10 ms radio frame, including I/Q data and control words. You can use this interface to support your specific application. For example, the AUX interface allows you to implement custom I/Q sample widths and custom mapping schemes.

The AUX interface also enables multi-hop routing applications and provides timing reference information for transmitted and received frames. Using this interface, you can load I/Q data in a precise location in the precise CPRI basic frame you target.

The AUX interface allows you to connect CPRI v6.0 IP core instances and other system components together by supporting a direct connection to a user-defined routing layer or custom mapping block. You implement this routing layer, which is not defined in the CPRI V6.0 Specification, outside the CPRI v6.0 IP core. The AUX interface supports the transmission and reception of I/Q data and timing information between an RE slave and an RE master, allowing you to define a custom routing layer that enables daisy-chain configurations of RE master and slave ports. Your custom routing layer determines the I/Q sample data to pass on to other REs to support multi-hop network configurations and custom mapping algorithms.

If you turn on **Enable auxiliary interface** in the CPRI v6.0 parameter editor, your IP core includes this interface.

## AUX Interface Signals

**Table 3-5: AUX Interface Signals**

If you turn on **Enable auxiliary interface** in the CPRI v6.0 parameter editor, the AUX interface is available. This interface allows access to the entire CPRI frame and has the highest priority among the L1 interfaces.

You can alter the transmit write latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter. The default transmit latency, when **Auxiliary and direct interfaces write latency cycle(s)** has the value of zero, is one `cpri_clkout` cycle. You can specify additional latency cycles.

All interface signals are clocked by the `cpri_clkout` clock.

| AUX RX Interface Status Signals |           |   |
|---------------------------------|-----------|---|
| Signal Name                     | Direction | Description   |
| <code>aux_rx_rfp</code>         | Output    | Synchronization pulse for start of 10 ms radio frame. The pulse occurs at the start of the radio frame on the AUX RX interface. |
| <code>aux_rx_hfp</code>         | Output    | Synchronization pulse for start of hyperframe. The pulse occurs at the start of the hyperframe on the AUX RX interface.         |
| <code>aux_rx_bfn[11:0]</code>   | Output    | Current radio frame number on the AUX RX interface.   |
| <code>aux_rx_z[7:0]</code>      | Output    | Current hyperframe number on the AUX RX interface. Value is in the range 0–149.   |

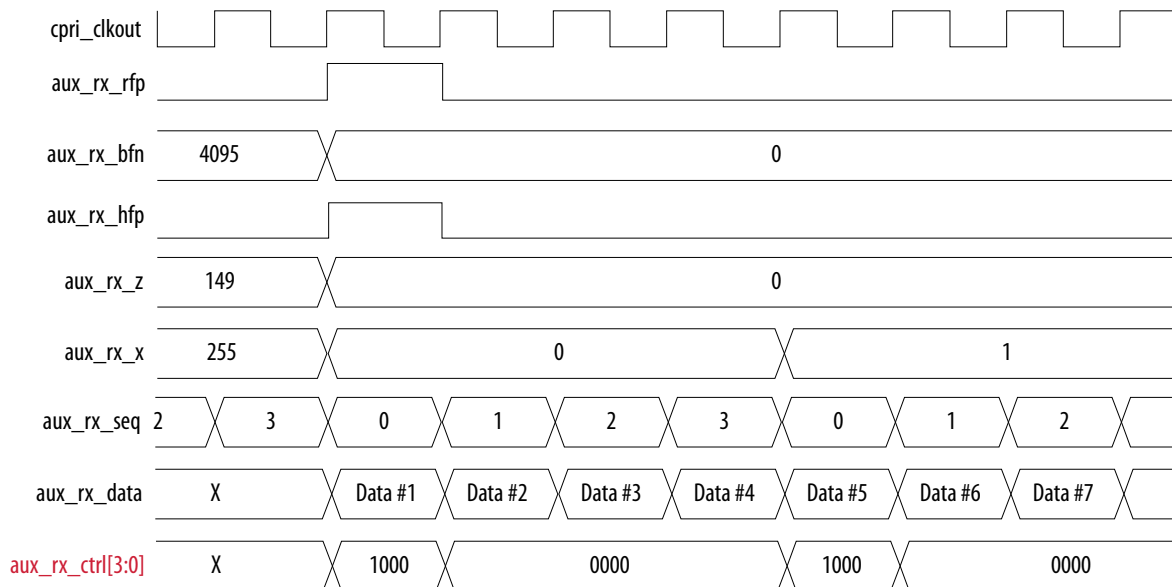
| AUX RX Interface Status Signals             |           |   |
|---|-----------|---|
| Signal Name                                 | Direction | Description   |
| aux_rx_x[7:0]                               | Output    | Index number of the current basic frame in the current hyperframe on the AUX RX interface. Value is in the range 0–255.   |
| aux_rx_seq[6:0]                             | Output    | Index number of the current 32-bit word in the current basic frame on the AUX RX interface. The value range depends on the current CPRI line bit rate: <ul style="list-style-type: none"> <li>• 0.6144 Gbps: range is 0–3</li> <li>• 1.2288 Gbps: range is 0–7</li> <li>• 2.4576 Gbps: range is 0–15</li> <li>• 3.0720 Gbps: range is 0–19</li> <li>• 4.9152 Gbps: range is 0–31</li> <li>• 6.1440 Gbps: range is 0–39</li> <li>• 8.11008 Gbps: range is 0–63</li> <li>• 9.8304 Gbps: range is 0–63</li> <li>• 10.1376 Gbps: range is 0–79</li> </ul> |
| AUX RX Interface Data Signals               |           |   |
| Signal Name                                 | Direction | Description   |
| aux_rx_data[31:0]                           | Output    | Data the IP core presents on the AUX link. Data is transmitted in 32-bit words. Byte [31:24] is transmitted first and byte [7:0] is transmitted last.   |
| aux_rx_ctrl[3:0]                            | Output    | Control slots indicator. Each asserted bit indicates that the corresponding byte position in <code>aux_rx_data</code> holds a byte from a CPRI control word.  |
| AUX TX Interface Control and Status Signals |           |   |
| Signal Name                                 | Direction | Description   |
| aux_tx_sync_rfp                             | Input     | Synchronization input used in REC master to control the start of a new 10 ms radio frame. Asserting this signal resets the frame synchronization machine. The CPRI v6.0 IP core uses the rising edge of the pulse for synchronization.  |
| aux_tx_err[3:0]                             | Output    | Indicates that in the previous <code>cpri_clkout</code> cycle, <code>aux_tx_mask</code> bits masked one or more control words in the target CPRI frame. Each bit in <code>aux_tx_err</code> indicates whether the corresponding byte in the 32-bit value on <code>aux_tx_data</code> overwrites a control word in the target CPRI frame.  |
| aux_tx_rfp                                  | Output    | Synchronization pulse for start of 10 ms radio frame. The pulse occurs at the start of the radio frame on the AUX TX interface.   |

| AUX TX Interface Control and Status Signals |           |  |
|---|-----------|--|
| Signal Name                                 | Direction | Description  |
| aux_tx_hfp                                  | Output    | Synchronization pulse for start of hyperframe. The pulse occurs at the start of the hyperframe on the AUX TX interface.  |
| aux_tx_bfn[11:0]                            | Output    | Current radio frame number on the AUX TX interface.  |
| aux_tx_z[7:0]                               | Output    | Current hyperframe number on the AUX TX interface. Value is in the range 0–149.  |
| aux_tx_x[7:0]                               | Output    | Index number of the current basic frame in the current hyperframe on the AUX TX interface. Value is in the range 0–255.  |
| aux_tx_seq[6:0]                             | Output    | <p>Index number of the current 32-bit word in the current basic frame on the AUX TX interface.</p> <p>The value range depends on the current CPRI line bit rate:</p> <ul style="list-style-type: none"> <li>• 0.6144 Gbps: range is 0–3</li> <li>• 1.2288 Gbps: range is 0–7</li> <li>• 2.4576 Gbps: range is 0–15</li> <li>• 3.0720 Gbps: range is 0–19</li> <li>• 4.9152 Gbps: range is 0–31</li> <li>• 6.1440 Gbps: range is 0–39</li> <li>• 8.11008 Gbps: range is 0–63</li> <li>• 9.8304 Gbps: range is 0–63</li> <li>• 10.1376 Gbps: range is 0–79</li> </ul>  |
| AUX TX Interface Data Signals               |           |  |
| Signal Name                                 | Direction | Description  |
| aux_tx_data[31:0]                           | Input     | <p>Data the IP core receives on the AUX TX interface. The data is aligned with <code>aux_tx_seq</code> with a write delay of one <code>cpri_clkout</code> cycle plus the number of additional <code>cpri_clkout</code> cycles you specify as the value of the <b>Auxiliary and direct interfaces write latency cycle(s)</b> parameter.</p> <p>User logic is responsible to ensure that the write data in <code>aux_tx_data</code> is aligned with the write latency value of the <b>Auxiliary and direct interfaces write latency cycle(s)</b> parameter.</p> <p>Data is received in 32-bit words. For correct transmission in the CPRI frame, you must send byte [31:24] first and byte [7:0] last.</p> |

| AUX TX Interface Data Signals |           |   |
|-------------------------------|-----------|---|
| Signal Name                   | Direction | Description   |
| aux_tx_mask[31:0]             | Input     | <p>Bit mask for insertion of data from aux_tx_data in the target CPRI frame.</p> <p>This signal aligns with aux_tx_data and therefore, aligns with aux_tx_seq with a delay of one cpri_clkout cycle plus the number of additional cpri_clkout cycles you specify as the value of the <b>Auxiliary and direct interfaces write latency cycle(s)</b> parameter.</p> <p>Assertion of a bit in this mask overrides insertion of data to the corresponding bit in the target CPRI frame from any other source. Therefore, you must deassert the mask bits during K28.5 character or /S/ /T/ insertion in the outgoing CPRI frame, which occurs when Z=X=0. If you do not deassert the mask bits during K28.5 or /S/ /T/ character insertion in the outgoing CPRI frame, the aux_tx_err output signal is asserted in the following cpri_clkout cycle.</p> |
| aux_tx_ctrl[3:0]              | Output    | Control slots indicator. Each asserted bit indicates that the corresponding byte position, as indicated by aux_tx_seq, should hold a CPRI control word in the target CPRI frame.  |

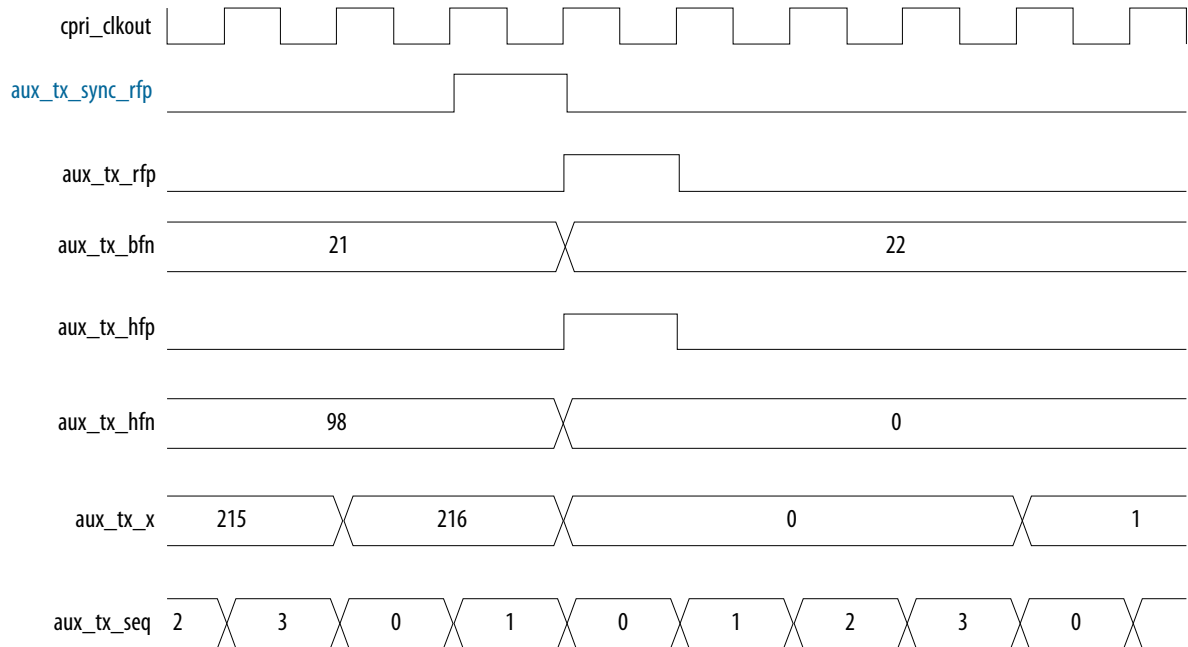
Figure 3-11: AUX RX Interface Timing Diagram

AUX RX interface behavior in a CPRI v6.0 IP core running at 0.6144 Gbps.



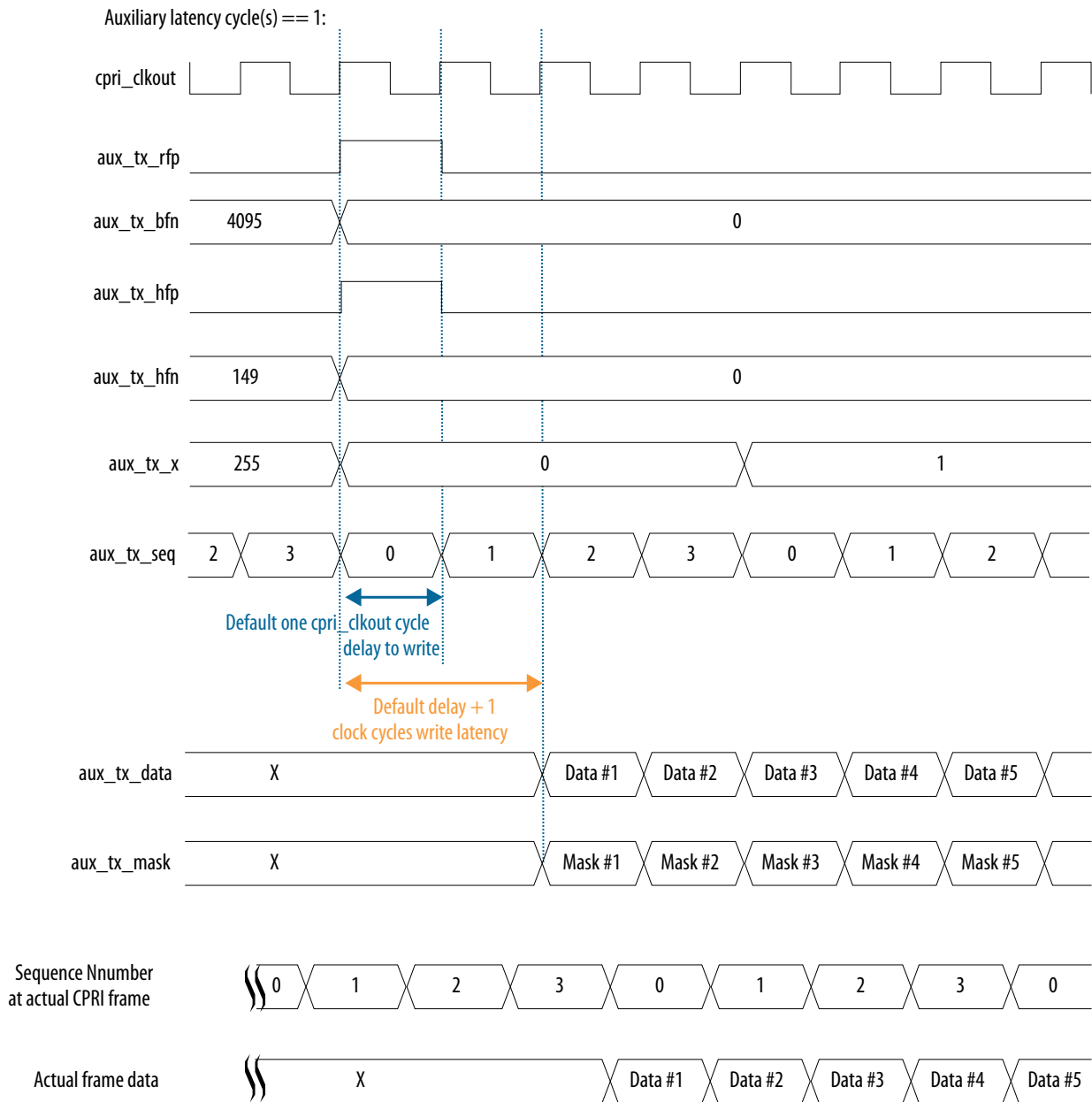
**Figure 3-12: CPRI REC Master Response to aux\_tx\_sync\_rfp Resynchronization Pulse**

Asserting `aux_tx_sync_rfp` resets the hyperframe and basic frame numbers in an REC master CPRI v6.0 IP core. Shown for a CPRI v6.0 IP core running at 0.6144 Gbps.



**Figure 3-13: AUX TX Interface Timing Diagram with One Auxiliary Latency Cycle**

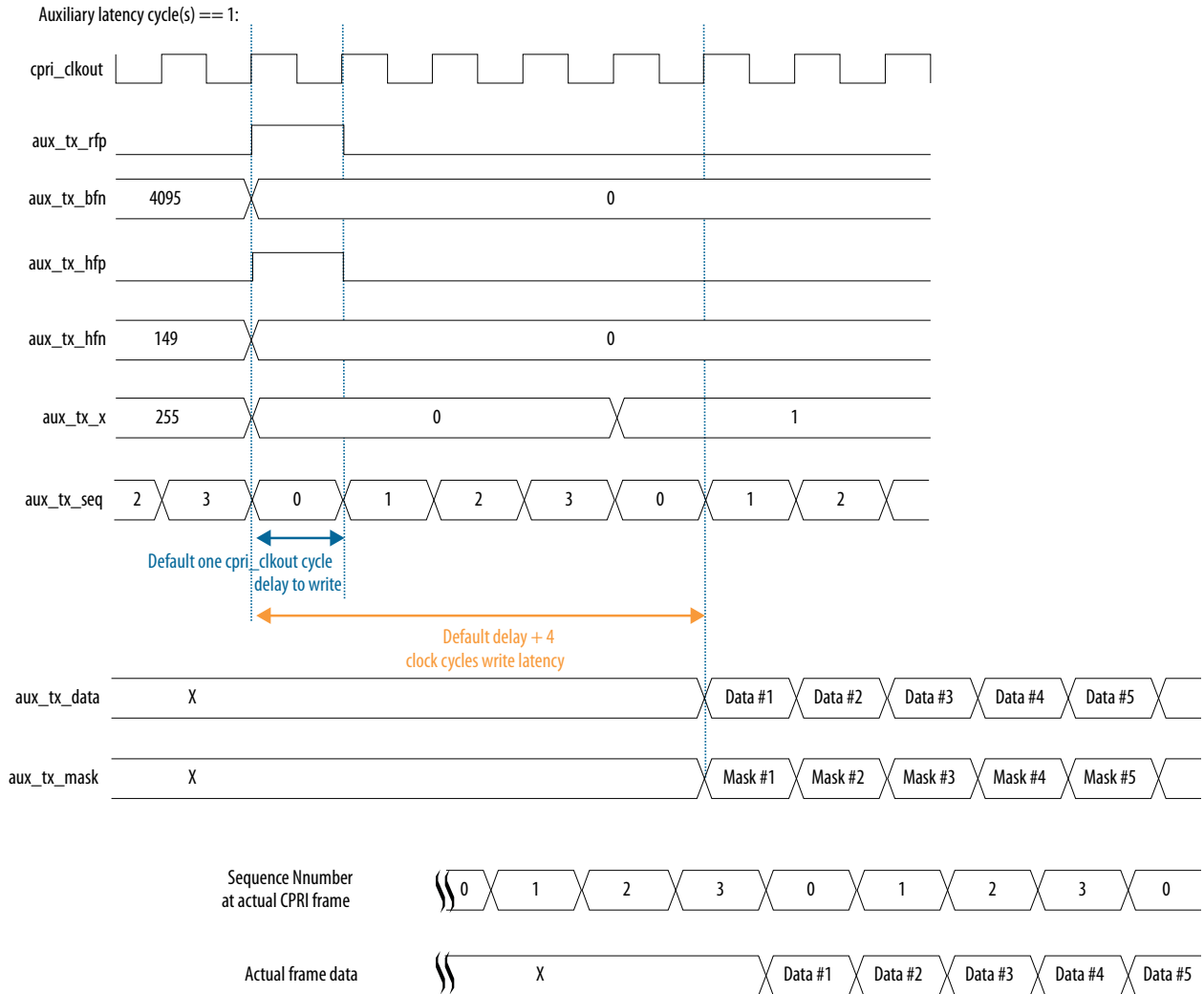
Expected behavior on the AUX TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps. Illustrates the effect of setting the **Auxiliary and direct interfaces write latency cycle(s)** parameter to a non-zero value. Shown for a CPRI v6.0 IP core with **Auxiliary and direct interfaces write latency cycle(s)** set to the value of 1.





**Figure 3-14: AUX TX Interface Timing Diagram with Four Auxiliary Latency Cycles**

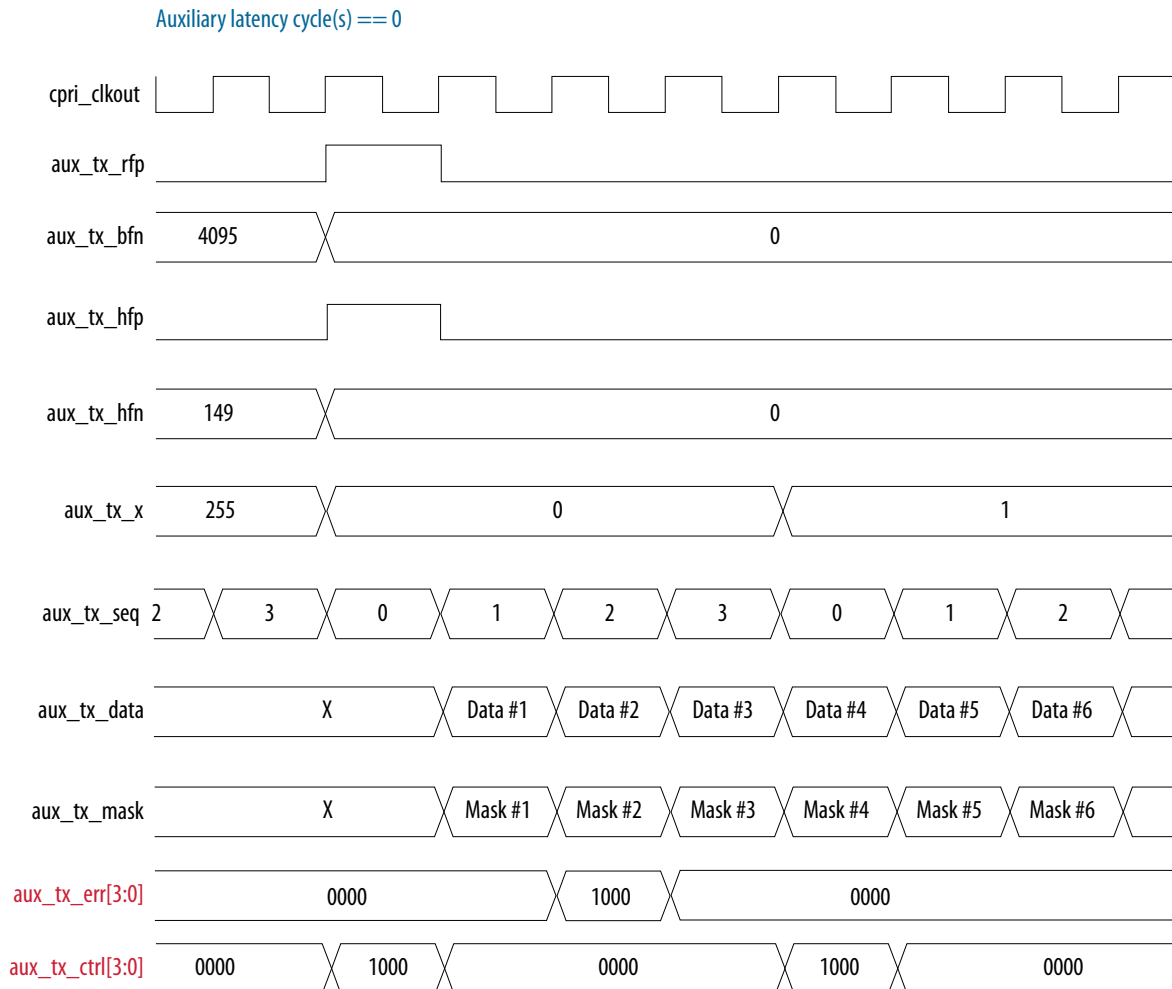
Expected behavior on the AUX TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps. Illustrates the effect of setting the **Auxiliary and direct interfaces write latency cycle(s)** parameter to the value of four.



**Figure 3-15: AUX TX Timing Diagram with Error**

Illustrates the behavior of the `aux_tx_err` signal on the AUX TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps. The `aux_tx_ctrl` signal shows that when `aux_tx_seq` has the value of zero, the first byte at the corresponding position in the target CPRI frame is a control byte. The value of the **Auxiliary and direct interfaces write latency cycle(s)** parameter is zero. Therefore, the data on `aux_tx_data` is delayed by one clock cycle from the value on `aux_tx_seq`. The data that appears on `aux_tx_data` when `aux_tx_seq` has the value of 1 is the data that targets position X.Y.Z.0 in the target CPRI frame.

The value of Mask #1 is presumably 0xFFXXXXXX, indicating that the incoming data on `aux_tx_data` is intended to overwrite this control byte in the target CPRI frame. Therefore, in the following `cpri_clkout` cycle, the IP core asserts the `aux_tx_err` signal.



**Related Information**

- [AUX Interface Synchronization](#) on page 3-26  
Illustrates the relationship between the AUX synchronization signals.

- [Auxiliary Latency Cycles](#) on page 3-26

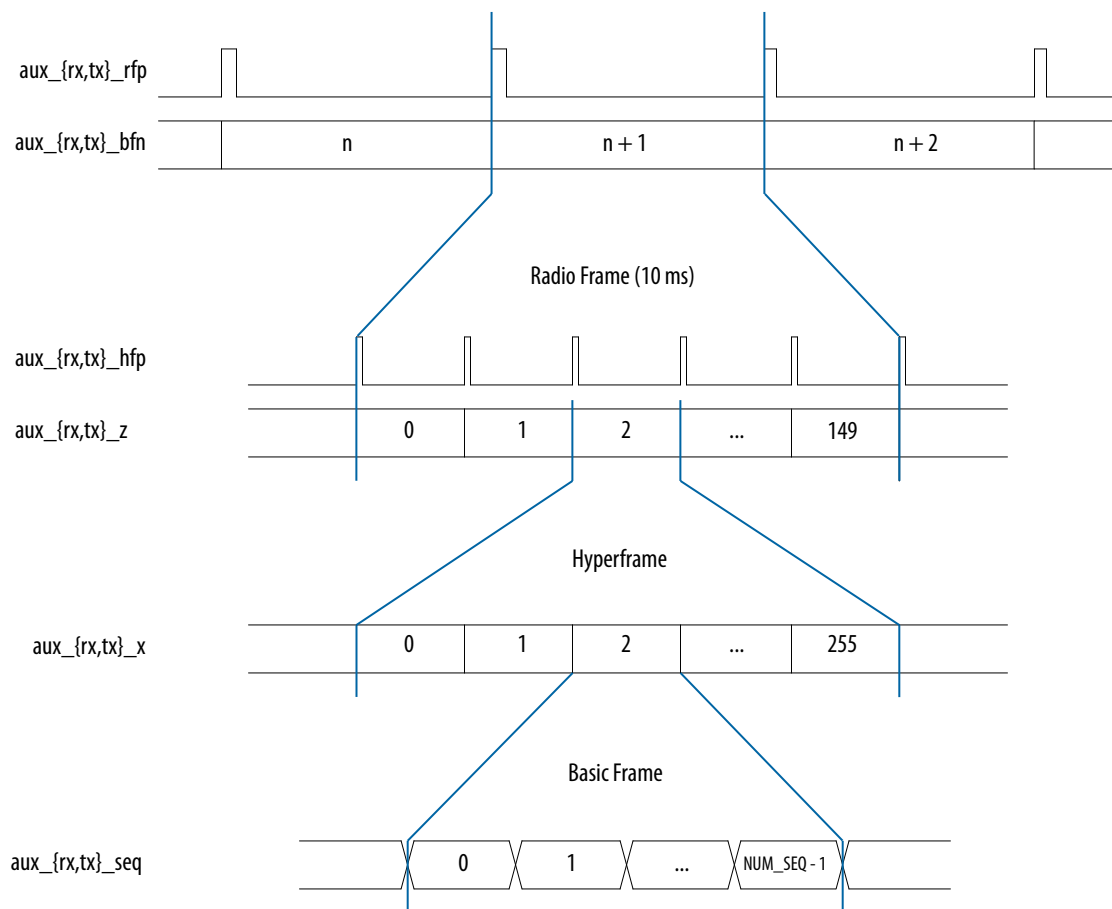
The **Auxiliary and direct interfaces write latency cycle(s)** parameter affects the relative timing of the data on the aux\_tx\_data and aux\_tx\_mask busses. This section provides an explanation of the parameter's effect and purpose.

## AUX Interface Synchronization

**Figure 3-16: Relationship Between Synchronization Pulses and Numbers on the AUX Interface**

The output synchronization signals are useful for custom user logic, including frame synchronization across hops in multi-hop configurations.

The output synchronization signals are derived from the CPRI frame synchronization state machine.



### Related Information

[AUX Interface Signals](#) on page 3-18

Describes the AUX interface signals and provides AUX interface timing diagrams.

## Auxiliary Latency Cycles

Intel provides configurable write latency on the AUX TX interface and other direct TX interfaces to support user logic with sufficient advance notice of the position in the CPRI frame. The processing time

that user logic requires after determining the current position in the CPRI frame is implementation specific, and the default write latency of a single `cpri_clkout` cycle might not be adequate. Using the **Auxiliary and direct interfaces write latency cycle(s)** parameter, you can set the write latency to the number of clock cycles required for your system to process data before sending it on the AUX TX interface or other direct TX interface.

In the CPRI v6.0 parameter editor, you can specify a non-zero number of **Auxiliary and direct interfaces write latency cycle(s)** to increase the write latency on the AUX TX interface and other direct TX interfaces to the CPRI v6.0 IP core.

The write latency is the number of `cpri_clkout` cycles from when the `aux_tx_seq` output signal has the value of `n` to when user logic must write data to the AUX TX interface to target the corresponding position in the CPRI frame. For other direct interfaces, the IP core notifies user logic when it is ready for input and the user does not need to monitor the `aux_tx_seq` signal. However, the **Auxiliary latency cycle(s)** value does apply to all of the direct interfaces.

When **Auxiliary and direct interfaces write latency cycle(s)** has the default value of zero, the write latency on the direct TX interfaces is one `cpri_clkout` cycle. When **Auxiliary and direct interfaces write latency cycle(s)** has the value of `N`, the write latency is  $(1+N)$  `cpri_clkout` cycles.

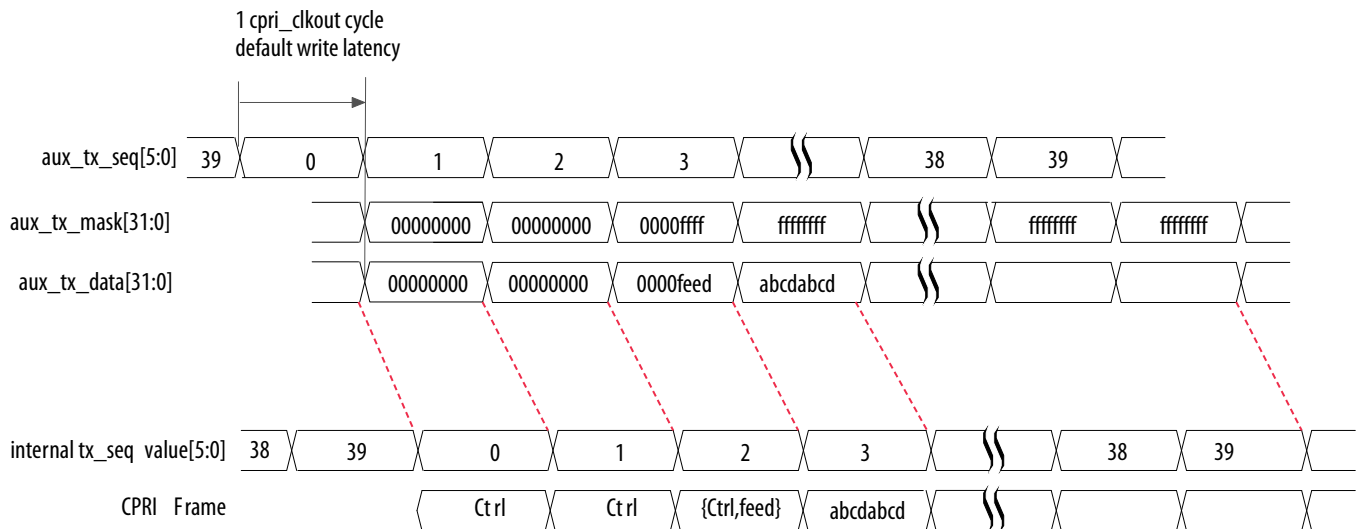
User logic is responsible to ensure that the data presented to the IP core on the AUX TX interface is presented at the correct write latency relative to the AUX TX interface synchronization signals.

**Note:** You cannot simply write to the AUX TX interface with a consistent write latency that you determine after configuring your IP core. If you do not specify the correct write latency in the CPRI v6.0 parameter editor, the data you present on the AUX TX interface will not fill the correct position in the target CPRI frame. To ensure the write latency offset is implemented correctly in the IP core, you must set the parameter.

**Figure 3-17: AUX Interface Transmit Write Latency**

Illustrates the transmit write latency on the AUX interface when **Auxiliary and direct interfaces write latency cycle(s)** has the value of 0. If you specify a non-zero value for this parameter, the latency increases from the default latency of one `cpri_clkout` cycle to 1 plus the number of cycles you specify.

In this example, the CPRI line bit rate is 6.144 Gbps, so that the control word is 10 bytes. User logic masks the control word, so that the IP core does not receive the control words from the AUX interface.



## Direct Interface CPRI Frame Data Format

The information on the AUX interface and all of the other direct interfaces except the L1 CSR interface, appears in the relevant data bus in 32-bit words. The CPRI v6.0 IP core converts the contents of the incoming CPRI frame to a 32-bit format internally. Similarly, the IP core expects to receive data on the various direct interfaces in this format. The only exception is the L1 CSR interface, which transmits and receives information in individual bits.

**Figure 3-18: AUX Interface Data at Different CPRI Line Bit Rates**

The AUX interface presents and expects data in fixed 32-bit words. The mapping of the CPRI frame to and from 32-bit words depends on the CPRI v6.0 IP core bit rate. This figure illustrates how CPRI frame words are mapped to 32-bit words on the AUX interface 32-bit data bus.

### 0.6144 Gbps

#### Line Rate:

|         | Sequence number on AUX interface |          |           |           |
|---------|----------------------------------|----------|-----------|-----------|
|         | 0                                | 1        | 2         | 3         |
| [31:24] | #Z.X.0.0 <sup>(1)</sup>          | #Z.X.4.0 | #Z.X.8.0  | #Z.X.12.0 |
| [23:16] | #Z.X.1.0                         | #Z.X.5.0 | #Z.X.9.0  | #Z.X.13.0 |
| [15:8]  | #Z.X.2.0                         | #Z.X.6.0 | #Z.X.10.0 | #Z.X.14.0 |
| [7:0]   | #Z.X.3.0                         | #Z.X.7.0 | #Z.X.11.0 | #Z.X.15.0 |

### 1.2288 Gbps

#### Line Rate:

|         | Sequence number on AUX interface |          |          |     |           |
|---------|----------------------------------|----------|----------|-----|-----------|
|         | 0                                | 1        | 2        | ... | 7         |
| [31:24] | #Z.X.0.0 <sup>(1)</sup>          | #Z.X.2.0 | #Z.X.4.0 | ... | #Z.X.14.0 |
| [23:16] | #Z.X.0.1 <sup>(1)</sup>          | #Z.X.2.1 | #Z.X.4.1 | ... | #Z.X.14.1 |
| [15:8]  | #Z.X.1.0                         | #Z.X.3.0 | #Z.X.5.0 | ... | #Z.X.15.0 |
| [7:0]   | #Z.X.1.1                         | #Z.X.3.1 | #Z.X.5.1 | ... | #Z.X.15.1 |

### 2.4576 Gbps

#### Line Rate:

|         | Sequence number on AUX interface |          |          |     |           |
|---------|----------------------------------|----------|----------|-----|-----------|
|         | 0                                | 1        | 2        | ... | 15        |
| [31:24] | #Z.X.0.0 <sup>(1)</sup>          | #Z.X.1.0 | #Z.X.2.0 | ... | #Z.X.15.0 |
| [23:16] | #Z.X.0.1 <sup>(1)</sup>          | #Z.X.1.1 | #Z.X.2.1 | ... | #Z.X.15.1 |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup>          | #Z.X.1.2 | #Z.X.2.2 | ... | #Z.X.15.2 |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup>          | #Z.X.1.3 | #Z.X.2.3 | ... | #Z.X.15.3 |

### 3.072 Gbps

#### Line Rate:

|         | Sequence number on AUX interface |                         |          |     |           |           |
|---------|----------------------------------|-------------------------|----------|-----|-----------|-----------|
|         | 0                                | 1                       | 2        | ... | 18        | 19        |
| [31:24] | #Z.X.0.0 <sup>(1)</sup>          | #Z.X.0.4 <sup>(1)</sup> | #Z.X.1.3 | ... | #Z.X.14.2 | #Z.X.15.1 |
| [23:16] | #Z.X.0.1 <sup>(1)</sup>          | #Z.X.1.0                | #Z.X.1.4 | ... | #Z.X.14.3 | #Z.X.15.2 |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup>          | #Z.X.1.1                | #Z.X.2.0 | ... | #Z.X.14.4 | #Z.X.15.3 |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup>          | #Z.X.1.2                | #Z.X.2.1 | ... | #Z.X.15.0 | #Z.X.15.4 |

**4.952 Gbps**

Line Rate:

|         |                         | Sequence number on AUX interface |          |     |           |           |    |
|---------|-------------------------|----------------------------------|----------|-----|-----------|-----------|----|
|         |                         | 0                                | 1        | 2   | ...       | 30        | 31 |
| [31:24] | #Z.X.0.0 <sup>(1)</sup> | #Z.X.0.4 <sup>(1)</sup>          | #Z.X.1.0 | ... | #Z.X.14.0 | #Z.X.15.4 |    |
| [23:16] | #Z.X.0.1 <sup>(1)</sup> | #Z.X.0.5 <sup>(1)</sup>          | #Z.X.1.1 | ... | #Z.X.14.1 | #Z.X.15.5 |    |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup> | #Z.X.0.6 <sup>(1)</sup>          | #Z.X.2.2 | ... | #Z.X.14.2 | #Z.X.15.6 |    |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup> | #Z.X.0.7 <sup>(1)</sup>          | #Z.X.2.3 | ... | #Z.X.15.3 | #Z.X.15.7 |    |

**6.144 Gbps**

Line Rate:

|         |                         | Sequence number on AUX interface |                         |     |           |           |    |
|---------|-------------------------|----------------------------------|-------------------------|-----|-----------|-----------|----|
|         |                         | 0                                | 1                       | 2   | ...       | 38        | 39 |
| [31:24] | #Z.X.0.0 <sup>(1)</sup> | #Z.X.0.4 <sup>(1)</sup>          | #Z.X.0.8 <sup>(1)</sup> | ... | #Z.X.15.2 | #Z.X.15.6 |    |
| [23:16] | #Z.X.0.1 <sup>(1)</sup> | #Z.X.0.5 <sup>(1)</sup>          | #Z.X.0.9 <sup>(1)</sup> | ... | #Z.X.15.3 | #Z.X.15.7 |    |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup> | #Z.X.0.6 <sup>(1)</sup>          | #Z.X.1.0                | ... | #Z.X.15.4 | #Z.X.15.8 |    |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup> | #Z.X.0.7 <sup>(1)</sup>          | #Z.X.1.1                | ... | #Z.X.15.5 | #Z.X.15.9 |    |

**8.11008, 9.8304 Gbps**

Line Rate:

|         |                         | Sequence number on AUX interface |                          |                          |     |            |            |    |
|---------|-------------------------|----------------------------------|--------------------------|--------------------------|-----|------------|------------|----|
|         |                         | 0                                | 1                        | 2                        | 3   | ...        | 62         | 63 |
| [31:24] | #Z.X.0.0 <sup>(1)</sup> | #Z.X.0.4 <sup>(1)</sup>          | #Z.X.0.8 <sup>(1)</sup>  | #Z.X.0.12 <sup>(1)</sup> | ... | #Z.X.15.8  | #Z.X.15.12 |    |
| [23:16] | #Z.X.0.1 <sup>(1)</sup> | #Z.X.0.5 <sup>(1)</sup>          | #Z.X.0.9 <sup>(1)</sup>  | #Z.X.0.13 <sup>(1)</sup> | ... | #Z.X.15.9  | #Z.X.15.13 |    |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup> | #Z.X.0.6 <sup>(1)</sup>          | #Z.X.0.10 <sup>(1)</sup> | #Z.X.0.14 <sup>(1)</sup> | ... | #Z.X.15.10 | #Z.X.15.14 |    |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup> | #Z.X.0.7 <sup>(1)</sup>          | #Z.X.0.11 <sup>(1)</sup> | #Z.X.0.15 <sup>(1)</sup> | ... | #Z.X.15.11 | #Z.X.15.15 |    |

**10.1376 Gbps**

Line Rate:

|         |                         | Sequence number on AUX interface |                          |                          |           |          |     |            |            |    |
|---------|-------------------------|----------------------------------|--------------------------|--------------------------|-----------|----------|-----|------------|------------|----|
|         |                         | 0                                | 1                        | 2                        | 3         | 4        | 5   | ...        | 62         | 79 |
| [31:24] | #Z.X.0.0 <sup>(1)</sup> | #Z.X.0.4 <sup>(1)</sup>          | #Z.X.0.8 <sup>(1)</sup>  | #Z.X.0.12 <sup>(1)</sup> | #Z.X.0.16 | #Z.X.1.0 | ... | #Z.X.15.12 | #Z.X.15.16 |    |
| [23:16] | #Z.X.0.1 <sup>(1)</sup> | #Z.X.0.5 <sup>(1)</sup>          | #Z.X.0.9 <sup>(1)</sup>  | #Z.X.0.13 <sup>(1)</sup> | #Z.X.0.17 | #Z.X.1.1 | ... | #Z.X.15.13 | #Z.X.15.17 |    |
| [15:8]  | #Z.X.0.2 <sup>(1)</sup> | #Z.X.0.6 <sup>(1)</sup>          | #Z.X.0.10 <sup>(1)</sup> | #Z.X.0.14 <sup>(1)</sup> | #Z.X.0.18 | #Z.X.1.2 | ... | #Z.X.15.14 | #Z.X.15.18 |    |
| [7:0]   | #Z.X.0.3 <sup>(1)</sup> | #Z.X.0.7 <sup>(1)</sup>          | #Z.X.0.11 <sup>(1)</sup> | #Z.X.0.15 <sup>(1)</sup> | #Z.X.0.19 | #Z.X.1.3 | ... | #Z.X.15.15 | #Z.X.15.19 |    |

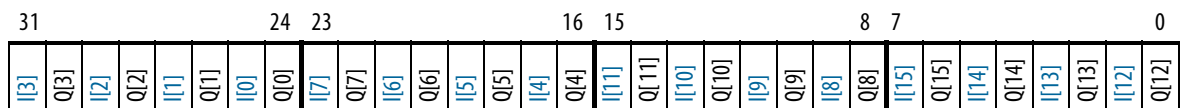
Note:

(1) Light blue table cells indicate control word bytes. Yellow table cells indicate real-time vendor specific bytes. White table cells indicate data word bytes.

The CPRI IP core passes the incoming AUX data through to the CPRI link unmodified. You must ensure that the incoming AUX data bits already include any CRC values expected by the application at the other end of the CPRI link.

**Figure 3-19: Data Sample Order on aux\_tx\_data and aux\_rx\_data Buses**

Illustrates how CPRI frame data is ordered in each 32-bit word.



## Direct IQ Interface

If you turn on **Enable direct IQ mapping interface** in the CPRI v6.0 parameter editor, the direct IQ interface is available. This interface allows direct access to the I/Q data time slots in the CPRI frame. You can connect this interface to any user-defined air standard I/Q mapping module.

This interface is Avalon-ST compliant with a read latency value of 1.

You can alter the transmit latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter.

**Table 3-6: Direct IQ Interface Signals**

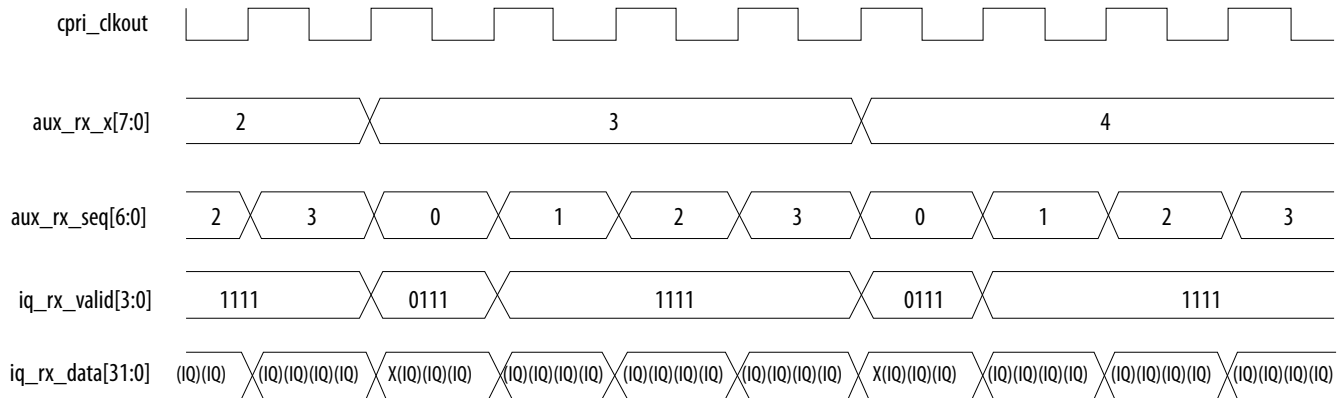
All interface signals are clocked by the `cpri_clkout` clock.

| Direct IQ RX Interface        |           |   |
|-------------------------------|-----------|---|
| Signal Name                   | Direction | Description   |
| <code>iq_rx_valid[3:0]</code> | Output    | Each asserted bit indicates the corresponding byte on the current <code>iq_rx_data</code> bus is valid I/Q data.  |
| <code>iq_rx_data[31:0]</code> | Output    | I/Q data received from the CPRI frame. The <code>iq_rx_valid</code> signal indicates which bytes are valid I/Q data bytes.  |
| Direct IQ TX Interface        |           |   |
| Signal Name                   | Direction | Description   |
| <code>iq_tx_ready[3:0]</code> | Output    | Each asserted bit indicates the IP core is ready to read I/Q data from the corresponding byte of <code>iq_tx_data</code> on the next clock cycle.   |
| <code>iq_tx_valid[3:0]</code> | Input     | Write valid for <code>iq_tx_data</code> . Assert bit [n] to indicate that the corresponding byte on the current <code>iq_tx_data</code> bus is valid I/Q data.  |
| <code>iq_tx_data[31:0]</code> | Input     | I/Q data to be written to the CPRI frame. The IP core writes the individual bytes of the current value on the <code>iq_tx_data</code> bus to the CPRI frame based on the <code>iq_tx_ready</code> signal from the previous cycle, and the <code>iq_tx_valid</code> signal in the current cycle. |

**Figure 3-20: Direct IQ RX Interface Timing Diagram**

Direct IQ RX interface behavior in a CPRI v6.0 IP core running at 0.6144 Gbps.

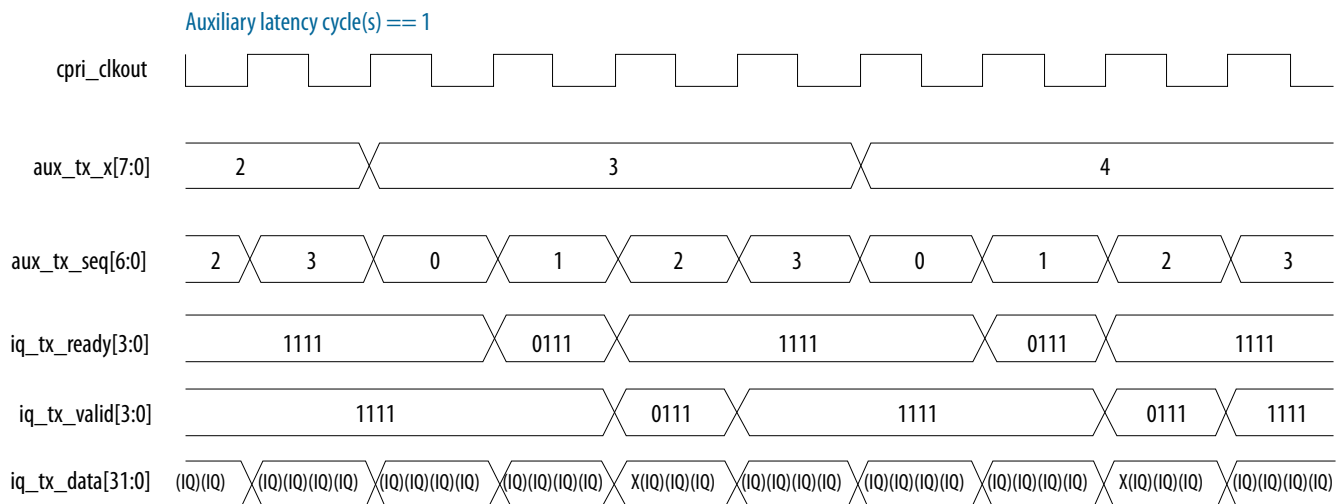
The `aux_rx_x` and `aux_rx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `iq_rx_valid` output signal that you use to identify the clock cycles with valid I/Q data.



**Figure 3-21: Direct IQ TX Interface Timing Diagram**

Expected behavior on the direct IQ TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps.

The `aux_tx_x` and `aux_tx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `iq_tx_ready` output signal that you use to identify the clock cycles when you can write I/Q data to the CPRI frame. Note that the write latency is two `cpri_clkout` clock cycles in this example.





**Related Information****Avalon Interface Specifications**

For more information about the Avalon-ST protocol, including timing diagrams, refer to the *Avalon Streaming Interfaces* chapter.

## Ctrl\_AxC Interface

If you turn on **Enable direct ctrl\_axc access interface** in the CPRI v6.0 parameter editor, the Ctrl\_AxC interface is available. This interface allows direct access to the Ctrl\_AxC subchannels in the CPRI frame, which are subchannels 4, 5, 6, and 7 in each hyperframe.

This interface is Avalon-ST compliant with a read latency value of 1.

You can alter the transmit latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter.

**Table 3-7: Ctrl\_AxC Interface Signals**

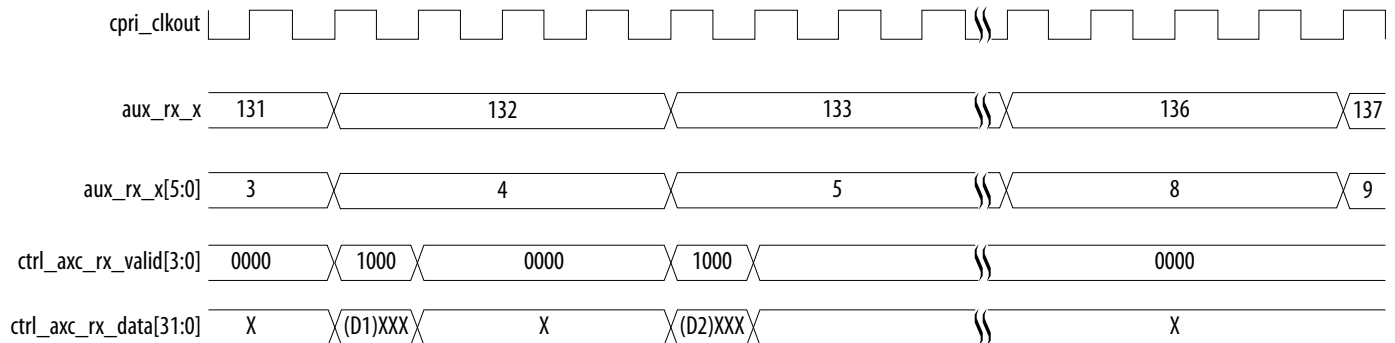
All interface signals are clocked by the `cpri_clkout` clock.

| Ctrl_AxC RX Interface               |           |  |
|-------------------------------------|-----------|--|
| Signal Name                         | Direction | Description  |
| <code>ctrl_axc_rx_valid[3:0]</code> | Output    | Each asserted bit indicates the corresponding byte on the current <code>ctrl_axc_rx_data</code> bus is valid Ctrl_AxC data.  |
| <code>ctrl_axc_rx_data[31:0]</code> | Output    | Ctrl_AxC data received from the CPRI frame. The <code>ctrl_axc_rx_valid</code> signal indicates which bytes are valid Ctrl_AxC data bytes.   |
| Ctrl_AxC TX Interface               |           |  |
| Signal Name                         | Direction | Description  |
| <code>ctrl_axc_tx_ready[3:0]</code> | Output    | Each asserted bit indicates the IP core is ready to read Ctrl_AxC data from the corresponding byte of <code>ctrl_axc_tx_data</code> on the next clock cycle.   |
| <code>ctrl_axc_tx_valid[3:0]</code> | Input     | Write valid for <code>ctrl_axc_tx_data</code> . Assert bit [n] to indicate that the corresponding byte on the current <code>ctrl_axc_tx_data</code> bus is valid Ctrl_AxC data.  |
| <code>ctrl_axc_tx_data[31:0]</code> | Input     | Ctrl_AxC data to be written to the CPRI frame. The IP core writes the individual bytes of the current value on the <code>ctrl_axc_tx_data</code> bus to the CPRI frame based on the <code>ctrl_axc_tx_ready</code> signal from the previous cycle, and the <code>ctrl_axc_tx_valid</code> signal in the current cycle. |

**Figure 3-22: Ctrl\_Axc RX Interface Timing Diagram**

Ctrl\_Axc RX interface behavior in a CPRI v6.0 IP core running at 0.6144 Gbps.

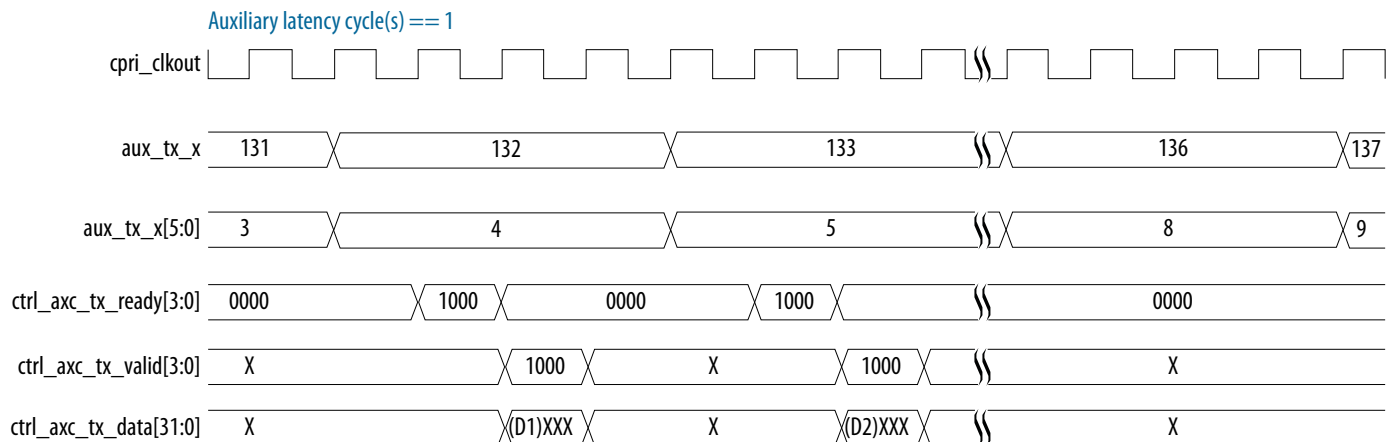
The `aux_rx_x` and `aux_rx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `ctrl_axc_rx_valid` output signal that you use to identify the clock cycles with valid Ctrl\_Axc data.



**Figure 3-23: Ctrl\_Axc TX Interface Timing Diagram**

Expected behavior on the Ctrl\_Axc TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps.

The `aux_tx_x` and `aux_tx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `ctrl_axc_tx_ready` output signal that you use to identify the clock cycles when you can write Ctrl\_Axc data to the CPRI frame. Note that the write latency is two `cpr_i_clkout` clock cycles in this example.



**Related Information**

**[Avalon Interface Specifications](#)**

For more information about the Avalon-ST protocol, including timing diagrams, refer to the *Avalon Streaming Interfaces* chapter.

## Direct Vendor Specific Access Interface

If you turn on **Enable direct vendor specific access interface** in the CPRI v6.0 parameter editor, the direct vendor specific access interface is available. This interface allows direct access to the Vendor Specific subchannels in the CPRI hyperframe. The Vendor Specific information is present only in subchannels 16 through (P-1) of the CPRI hyperframe, where P is the Fast C&M pointer value. Check the `vs_rx_valid` and `vs_tx_ready` signals to ensure you read and write this interface at the time that corresponds to the correct position in the CPRI frame. If you implement the AUX interface, you can read the value on the `aux_rx_x` or `aux_tx_x` output signal to identify the current position in the frame.

This interface is Avalon-ST compliant with a read latency value of 1.

You can alter the transmit latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter.

**Table 3-8: Direct Vendor Specific Access Interface Signals**

All interface signals are clocked by the `cpri_clkout` clock.

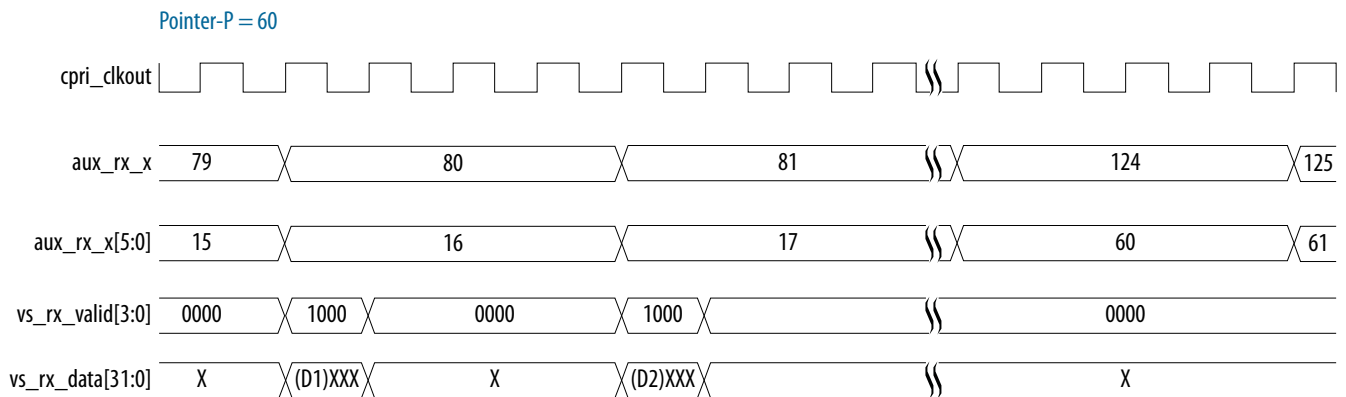
| Direct Vendor Specific RX Interface |           |   |
|-------------------------------------|-----------|---|
| Signal Name                         | Direction | Description   |
| <code>vs_rx_valid[3:0]</code>       | Output    | Each asserted bit indicates the corresponding byte on the current <code>vs_rx_data</code> bus is a valid vendor-specific byte.  |
| <code>vs_rx_data[31:0]</code>       | Output    | Vendor-specific word received from the CPRI frame. The <code>vs_rx_valid</code> signal indicates which bytes are valid vendor-specific bytes.   |
| Direct Vendor Specific TX Interface |           |   |
| Signal Name                         | Direction | Description   |
| <code>vs_tx_ready[3:0]</code>       | Output    | Each asserted bit indicates the IP core is ready to receive a vendor-specific byte from the corresponding byte of <code>vs_tx_data</code> on the next clock cycle.  |
| <code>vs_tx_valid[3:0]</code>       | Input     | Write valid for <code>vs_tx_data</code> . Assert bit [n] of <code>vs_tx_valid</code> to indicate that byte [n] on the <code>vs_tx_data</code> bus holds a valid value in the current clock cycle.   |
| <code>vs_tx_data[31:0]</code>       | Input     | Vendor-specific word to be written to the CPRI frame. The IP core writes the individual bytes of the current value on the <code>vs_tx_data</code> bus to the CPRI frame based on the <code>vs_tx_ready</code> signal from the previous cycle, and the <code>vs_tx_valid</code> signal in the current cycle. |

**Figure 3-24: Direct VS RX Timing Diagram**

Direct VS RX interface behavior in a CPRI v6.0 IP core running at 0.6144 Gbps.

The `aux_rx_x` signal is not part of this interface and is available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, its presence in the timing diagram explains the timing of the `vs_rx_valid` output signal that you use to identify the clock cycles with valid VS data.

The `aux_rx_x[7:0]` signal (labelled simply `aux_rx_x`) holds the eight-bit index of the basic frame in the hyperframe, from the perspective of the AUX interface. The subchannel index is the control word index modulo 64, available in `aux_rx_x[5:0]` if you turn on the AUX interface in your CPRI IP core.



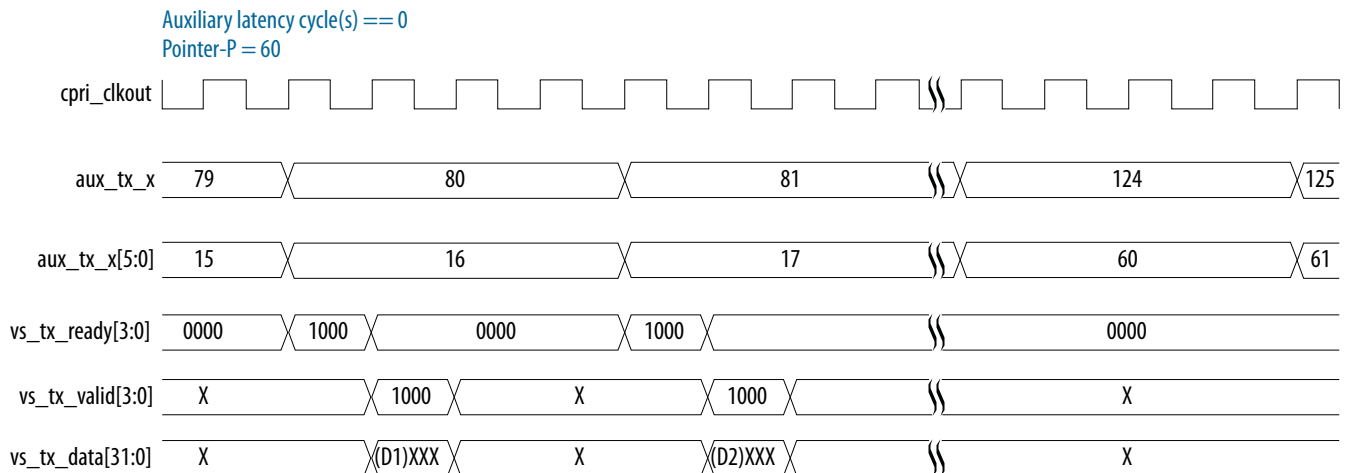
**Figure 3-25: Direct VS TX Timing Diagram**

Expected behavior on the direct VS TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps.

The `aux_tx_x` signal is not part of this interface and is available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, its presence in the timing diagram explains the timing of the `vs_tx_ready` output signal that you use to identify the clock cycles when you can write VS data to the CPRI frame.

The `aux_tx_x[7:0]` signal (labelled simply `aux_tx_x`) holds the eight-bit index of the basic frame in the hyperframe, from the perspective of the AUX interface. The subchannel index is the control word index modulo 64, available in `aux_tx_x[5:0]` if you turn on the AUX interface in your CPRI IP core.

Note that the write latency is one `cpri_clkout` clock cycle in this example.



### Related Information

#### Avalon Interface Specifications

For more information about the Avalon-ST protocol, including timing diagrams, refer to the *Avalon Streaming Interfaces* chapter.

## Real-Time Vendor Specific Interface

If you turn on **Enable direct real-time vendor specific interface** in the CPRI v6.0 parameter editor, the real-time vendor specific interface is available. This interface allows direct access to the Real Time Vendor Specific words in the CPRI hyperframe. Check the `rtvs_rx_valid` and `rtvs_tx_ready` signals to ensure you read and write this interface at the time that corresponds to the correct position in the CPRI frame. If you implement the AUX interface, you can read the value on the `aux_rx_seq` or `aux_tx_seq` output signal to identify the current position in the frame.

This option is only available if you specify a CPRI line bit rate of 10.1376 Gbps for your IP core.

This interface is Avalon-ST compliant with a read latency value of 1.

You can alter the transmit write latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter.

**Table 3-9: Real-Time Vendor Specific Interface Signals**

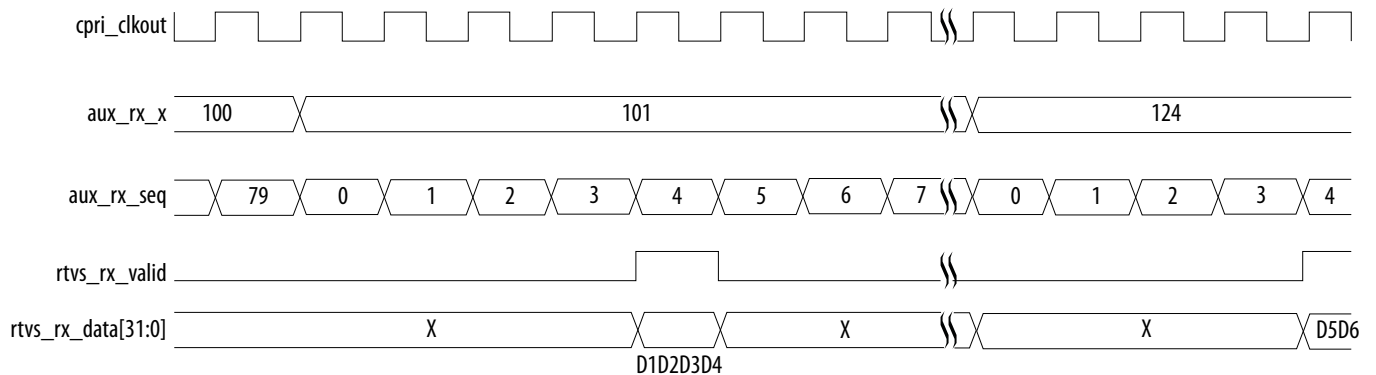
All interface signals are clocked by the `cpri_clkout` clock.

| Real-Time Vendor Specific RX Interface |           |   |
|--|-----------|---|
| Signal Name                            | Direction | Description   |
| <code>rtvs_rx_valid</code>             | Output    | Each asserted bit indicates the corresponding byte on the current <code>rtvs_rx_data</code> bus is a valid real-time vendor-specific byte.  |
| <code>rtvs_rx_data[31:0]</code>        | Output    | Real-time vendor-specific word received from the CPRI frame. The <code>rtvs_rx_valid</code> signal indicates which bytes are valid real-time vendor-specific bytes.   |
| Real-Time Vendor Specific TX Interface |           |   |
| Signal Name                            | Direction | Description   |
| <code>rtvs_tx_ready</code>             | Output    | Indicates the IP core is ready to read a real-time vendor-specific byte from <code>rtvs_tx_data</code> on the next clock cycle.   |
| <code>rtvs_tx_valid</code>             | Input     | Write valid for <code>rtvs_tx_data</code> . Assert this signal to indicate <code>rtvs_tx_data</code> holds a valid value in the current clock cycle.  |
| <code>rtvs_tx_data[31:0]</code>        | Input     | Real-time vendor-specific word to be written to the CPRI frame. The IP core writes the current value of the <code>rtvs_tx_data</code> bus to the CPRI frame based on the <code>rtvs_tx_ready</code> signal from the previous cycle, and the <code>rtvs_tx_valid</code> signal in the current cycle. |

**Figure 3-26: Direct RTVS RX Timing Diagram**

Direct RTVS RX interface behavior in a CPRI v6.0 IP core running at 10.1376 Gbps.

The `aux_rx_x` and `aux_rx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `rtvs_rx_valid` output signal that you use to identify the clock cycles with valid RTVS data.

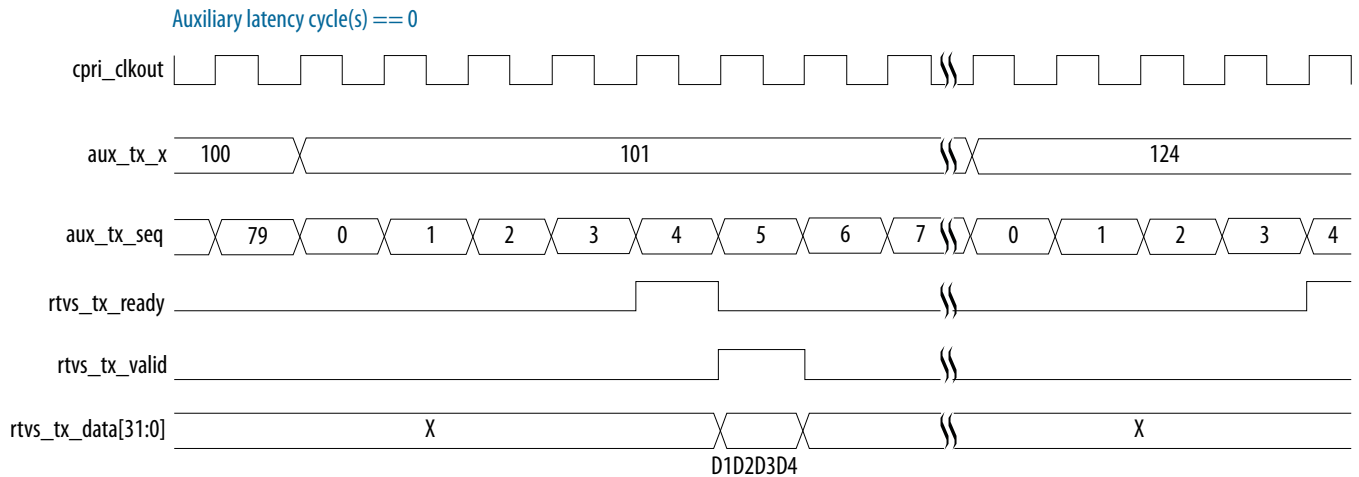


**Figure 3-27: Direct RTVS TX Timing Diagram**

Expected behavior on the direct RTVS TX interface of a CPRI v6.0 IP core running at 10.1376 Gbps.

The `aux_tx_x` and `aux_tx_seq` signals are not part of this interface and are available only if you turn on the AUX interface in your CPRI v6.0 IP core variation. However, their presence in the timing diagram explains the timing of the `rtvs_tx_ready` output signal that you use to identify the clock cycles when you can write RTVS data to the CPRI frame.

Note that the write latency is one `cpri_clkout` clock cycle in this example.



#### Related Information

##### [Avalon Interface Specifications](#)

For more information about the Avalon-ST protocol, including timing diagrams, refer to the *Avalon Streaming Interfaces* chapter.

## Direct HDLC Serial Interface

If you turn on **Enable direct HDLC serial interface** in the CPRI v6.0 parameter editor, the direct HDLC serial interface is available. This interface allows direct access to the slow control and management data in the CPRI frame. You can connect this interface to a user-defined HDLC PCS and MAC.

This interface is Avalon-ST compliant with a read latency value of 1.

You can alter the transmit write latency with the **Auxiliary and direct interfaces write latency cycle(s)** parameter. However, you do not need to view the `aux_tx_seq` signal for correct alignment. You can monitor the `hdlc_rx_valid` and `hdlc_tx_ready` signals to discover the correct times to read and write data on this interface.

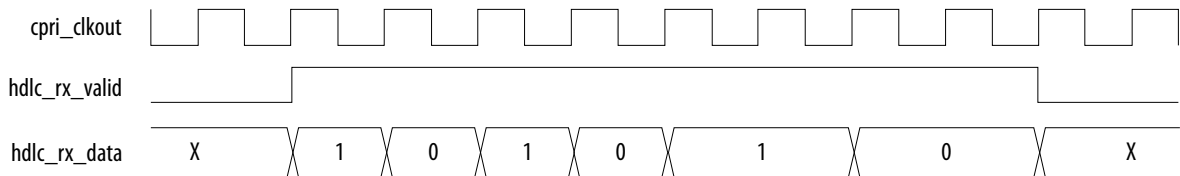
**Table 3-10: Direct HDLC Serial Interface Signals**

All interface signals are clocked by the `cpri_clkout` clock.

| Direct HDLC Serial RX Interface |           |   |
|---------------------------------|-----------|---|
| Signal Name                     | Direction | Description   |
| hdlc_rx_valid                   | Output    | When asserted, indicates hdlc_rx_data holds a valid HDLC bit in the current clock cycle.  |
| hdlc_rx_data                    | Output    | HDLC data stream received from the CPRI frame. The hdlc_rx_valid signal indicates which bits are valid HDLC bytes.  |
| Direct HDLC Serial TX Interface |           |   |
| Signal Name                     | Direction | Description   |
| hdlc_tx_ready                   | Output    | When asserted, indicates the IP core is ready to receive HDLC data from hdlc_tx_data on the next clock cycle.   |
| hdlc_tx_valid                   | Input     | Write valid for hdlc_tx_data. Assert this signal to indicate that hdlc_tx_data holds a valid HDLC bit in the current clock cycle.   |
| hdlc_tx_data                    | Input     | HDLC data stream to be written to the CPRI frame directly. The IP core writes the current value on hdlc_tx_data to the CPRI frame based on the hdlc_tx_ready signal from the previous cycle, and the hdlc_tx_valid signal in the current cycle. |

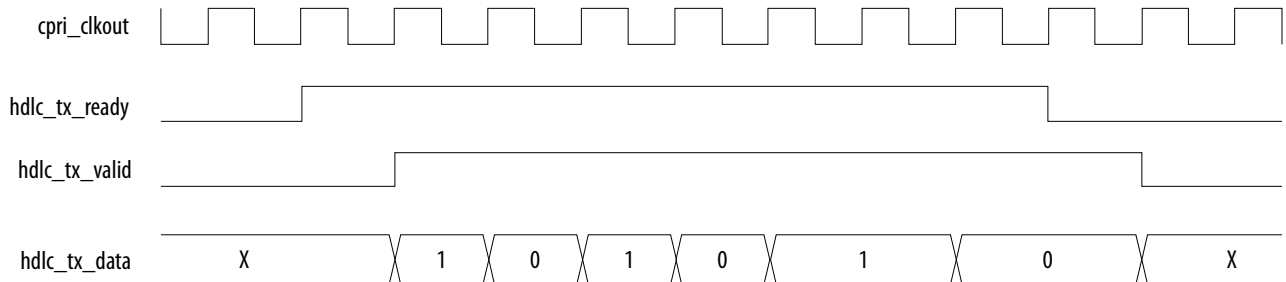
**Figure 3-28: Direct HDLC Serial RX Timing Diagram**

HDLC Serial RX interface behavior in a CPRI v6.0 IP core running at 0.6144 Gbps.



**Figure 3-29: Direct HDLC Serial TX Timing Diagram**

Expected behavior on the HDLC Serial TX interface of a CPRI v6.0 IP core running at 0.6144 Gbps.





**Related Information****Avalon Interface Specifications**

For more information about the Avalon-ST protocol, including timing diagrams, refer to the *Avalon Streaming Interfaces* chapter.

## Direct L1 Control and Status Interface

If you turn on **Enable direct Z.130.0 alarm bits access interface** in the CPRI v6.0 parameter editor, the direct L1 control and status interface is available. This interface provides direct access to the Z.130.0 alarm and reset signals (loss of frame (LOF), loss of signal (LOS), service access point (SAP) defect indication (SDI), remote alarm indication (RAI), and reset request or acknowledge) in the CPRI hyperframe.

If you connect the AUX interface of your RE slave IP core to a network switch or other routing layer rather than directly to the downstream RE master, or if you do not fully connect the AUX interface to the downstream RE master, you can use this Z.130.0 access interface to streamline the transfer of reset requests and SDI alarms across hops.

This interface has higher transmit priority than access through the CPRI v6.0 IP core registers.

This interface has the following types of signals:

- `_local_` signals are output signals from the IP core about the state of this IP core, and also indicate the IP core will assert the relevant outgoing Z.130.0 bit in the next CPRI hyperframe according to the transmit priority of this interface.
- `_assert` signals are input signals the application can use to request that the IP core assert the relevant outgoing Z.130.0 bit in the next CPRI hyperframe according to the transmit priority of this interface. You can also connect these signals in an RE master to the corresponding `_req` output signals of the upstream RE slave in a multi-hop configuration, to support efficient transfer of reset requests and SDI alarms to the IP core.
- `_remote` signals are output signals from the IP core that indicate the IP core received a Z.130.0 byte on the CPRI link with the relevant bit asserted by the CPRI link partner.
- `_req` signals are also output signals from the IP core that indicate the IP core received a Z.130.0 byte on the CPRI link with the relevant bit asserted by the CPRI link partner. However, these signals are intended to be passed downstream in a multi-hop configuration. If the IP core is an RE slave, and it connects to an RE master through the Z.130.0 alarm and reset interface in a multi-hop configuration, you can connect the RE slave IP core `_req` output signal directly to the corresponding `_assert` input signal on the downstream RE master for efficient communication of the reset request or SDI alarm.

**Table 3-11: Direct L1 Control and Status Interface Signals**

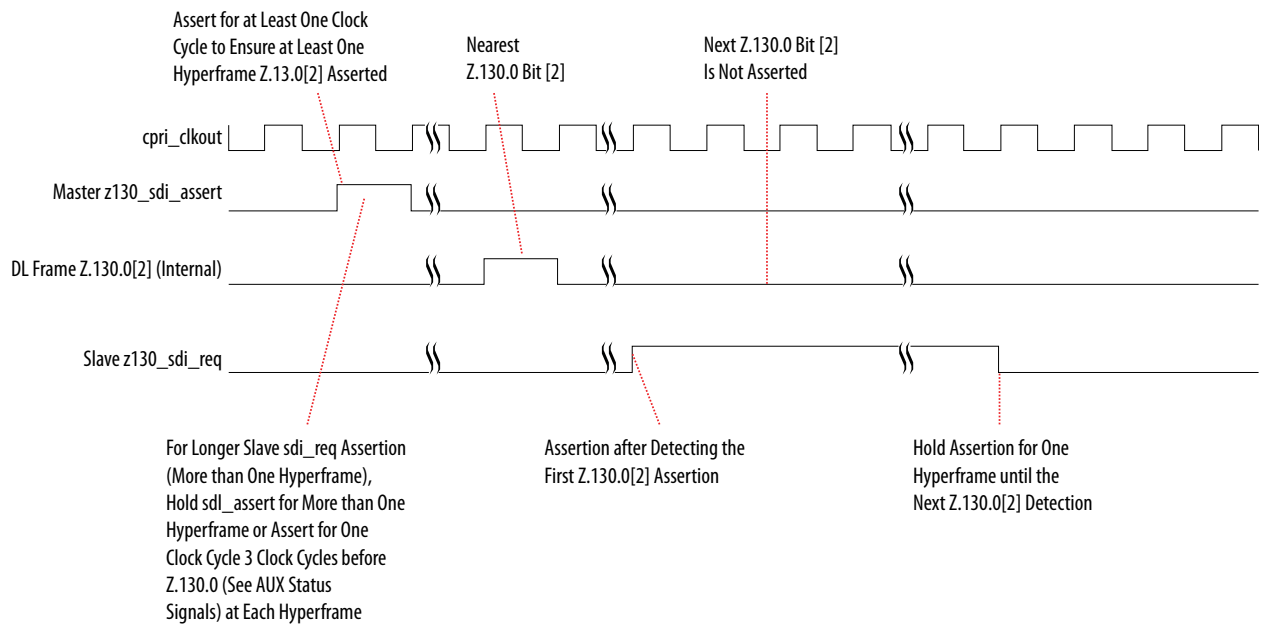
All interface signals are clocked by the `cpri_clkout` clock.

| Signal Name                 | Direction | Description   |
|-----------------------------|-----------|---|
| <code>z130_local_lof</code> | Output    | Indicates the IP core has detected a local loss of frame. In this case, the <code>state_l1_synch</code> output signal indicates the L1 synchronization state machine is in state XACQ1 or XACQ2.<br><br>In this case the IP core also asserts the <code>local_lof</code> bit in the <code>FLSAR</code> register at offset 0x2C. |

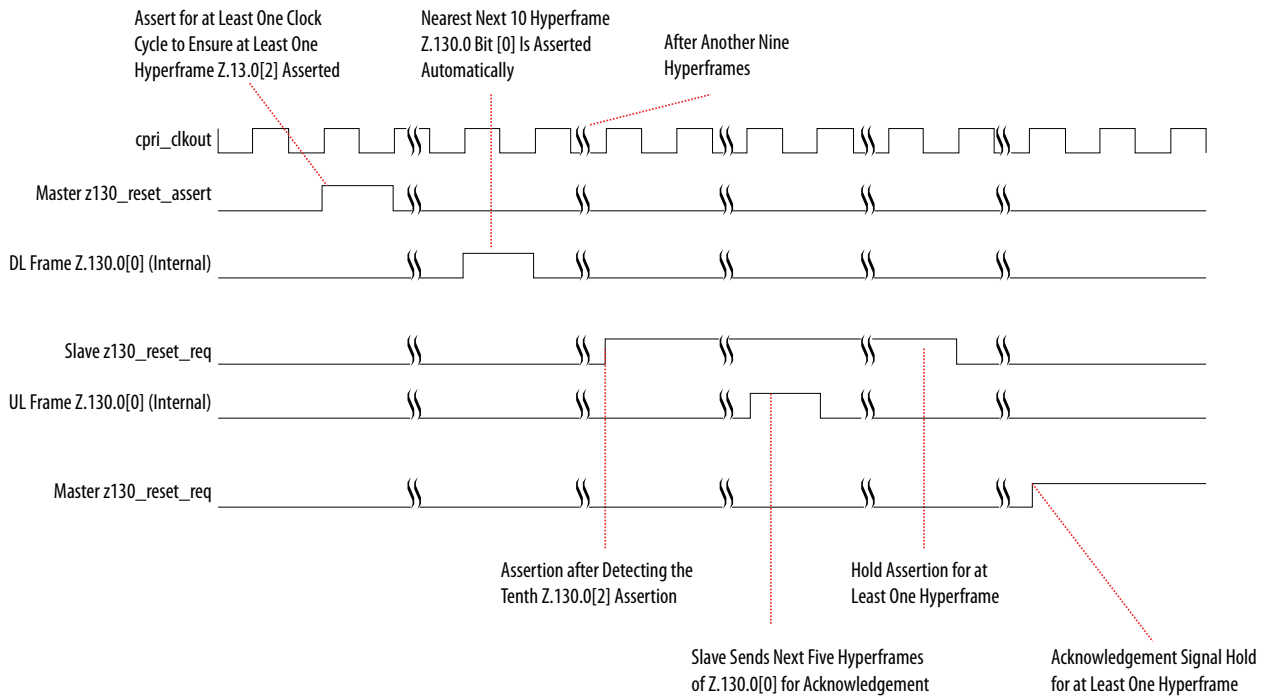
| Signal Name       | Direction | Description  |
|-------------------|-----------|--|
| z130_local_los    | Output    | Indicates the IP core has detected a local loss of signal. The IP core asserts this flag if it detects excessive 8B/10B errors that trigger the assertion of the optional L1 debug <code>rx_lcv</code> output signal or the <code>xcvr_los</code> output signal and the <code>rx_los</code> field of the <code>L1_CONFIG</code> register.<br><br>In this case the IP core also asserts the <code>local_los</code> bit in the <code>FLSAR</code> register at offset <code>0x2C</code> . |
| z130_sdi_assert   | Input     | Indicates that the master service access point (SAP) is not available. Possible causes for this situation are equipment error or that the connected slave IP core is forwarding an SDI request it detected to the current RE CPRI master IP core through a direct connection.  |
| z130_local_rai    | Output    | Indicates that either the <code>z130_local_lof</code> or the <code>z130_local_los</code> signal is high; clears when both of those two signals are low. Logical OR of two output signals <code>z130_local_lof</code> and <code>z130_local_los</code> .   |
| z130_reset_assert | Input     | Reset request from the application or from an RE slave to the current RE CPRI master IP core through a direct connection.  |
| z130_remote_lof   | Output    | Indicates LOF received in Z.130.0 control byte from remote CPRI link partner.<br><br>In this case the IP core also asserts the <code>remote_lof</code> bit in the <code>FLSAR</code> register at offset <code>0x2C</code> .  |
| z130_remote_los   | Output    | Indicates LOS received in Z.130.0 control byte from remote CPRI link partner.<br><br>In this case the IP core also asserts the <code>remote_los</code> bit in the <code>FLSAR</code> register at offset <code>0x2C</code> .  |
| z130_sdi_req      | Output    | Indicates remote SAP defect indication received in Z.130.0 control byte from remote CPRI link master. If the current CPRI IP core is an RE slave in a multi-hop configuration, you should connect this output signal directly to the <code>z130_sdi_assert</code> input signal of the downstream RE master.  |
| z130_remote_rai   | Output    | Asserts when either <code>z130_remote_lof</code> or <code>z130_remote_los</code> is asserted, and clears when both <code>z130_remote_lof</code> and <code>z130_remote_los</code> have the value of 0.<br><br>In this case the IP core also asserts the <code>rai_detected</code> bit in the <code>FLSAR</code> register at offset <code>0x2C</code> .  |

| Signal Name    | Direction | Description   |
|----------------|-----------|---|
| z130_reset_req | Output    | <p>If the current IP core is a CPRI link slave, indicates the IP core received a reset request in the Z.130.0 control byte from the remote CPRI link master.</p> <p>If the current IP core is a CPRI link master, indicates the IP core received a reset acknowledgement in the Z.130.0 control byte from the remote CPRI link slave.</p> |

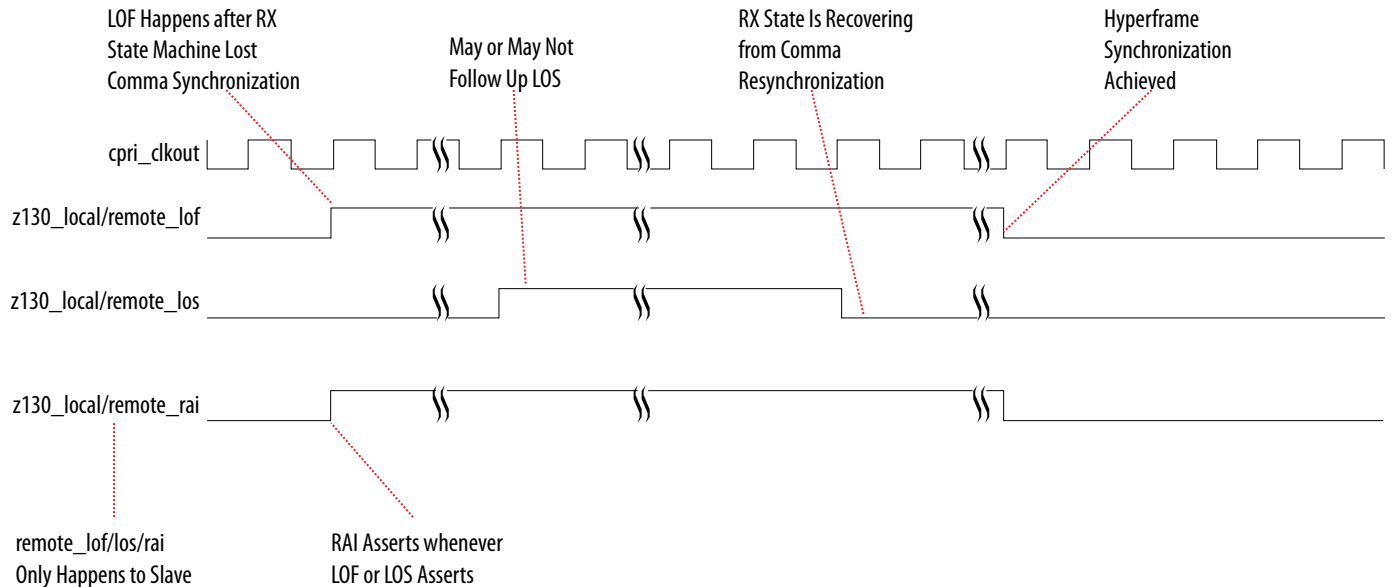
Figure 3-30: sdi\_assert to sdi\_req on Direct L1 Control and Status Interface



**Figure 3-31: reset\_assert to reset\_req on Direct L1 Control and Status Interface**



**Figure 3-32: LOF, LOS, and RAI on Direct L1 Control and Status Interface**



**Related Information**

[FLSAR Register](#) on page 5-11

## L1 Debug Interface

If you turn on **Enable L1 debug interfaces** in the CPRI v6.0 parameter editor, the L1 debug interface is available.

**Table 3-12: Direct L1 Control and Status Interface Signals**

All of the L1 debug signals are asynchronous.

| Signal Name   | Direction | Description  |
|---------------|-----------|--|
| rx_lcv        | Output    | Indicates the IP core has detected excessive 8B10B errors received.<br><br>The IP core asserts this signal when it detects more than 15 bits of error.   |
| rx_freq_alarm | Output    | Indicates the CPRI receive clock (receiver CDR recovered clock) and the main IP core clock ( <code>cpri_clkout</code> ) have a PPM difference. The IP core asserts this alarm each time it detects a mismatch. |

## Media Independent Interface (MII) to External Ethernet Block

The media independent interface (MII) allows the CPRI v6.0 IP core to communicate directly with an external Ethernet MAC block. If you set the value of the **Ethernet PCS interface** parameter in the CPRI v6.0 parameter editor to **MII**, your IP core includes this interface.

The MII supports the bandwidth described in the CPRI v6.0 Specification in Table 12, Achievable Ethernet bit rates.

**Table 3-13: MII Signals**

These signals are available if you set the value of the **Ethernet PCS interface** parameter in the CPRI v6.0 parameter editor to **MII**. You can connect a user-defined Ethernet MAC to this interface.

The interface is fully compliant to the IEEE 802.3 100BASE-X 100Mbps MII specification. An Ethernet PCS block in the CPRI v6.0 IP core ensures the interface bandwidth matches the current CPRI line bit rate and accesses data at the correct CPRI frame positions according to the Z.194.0 pointer value.

You must monitor the MII FIFO status signals and ensure you do not overflow or underflow the FIFO.

The interface signals are clocked by the `mii_rxclk` or `mii_txclk` clock.

| RX MII Signals |           |  |
|----------------|-----------|--|
| Signal Name    | Direction | Description  |
| mii_rxclk      | Input     | Clocks the MII receiver interface. You must drive this clock at the frequency of 25 MHz to achieve the 100 Mbps bandwidth required for this interface. |
| mii_rxreset_n  | Input     | Resets the MII receiver interface and FIFO read logic. This reset signal is active low.  |

| RX MII Signals                       |           |   |
|--------------------------------------|-----------|---|
| Signal Name                          | Direction | Description   |
| <code>mii_rxdv</code>                | Output    | Ethernet receive data valid. Indicates the presence of valid data or initial K nibble on <code>mii_rxd[3:0]</code> .  |
| <code>mii_rxer</code>                | Output    | Ethernet receive error. Indicates an error in the current nibble of <code>mii_rxd</code> . This signal is de-asserted at reset, and remains de-asserted while the CPRI v6.0 IP core is resetting and until link initialization completes.   |
| <code>mii_rxd[3:0]</code>            | Output    | Ethernet receive nibble data. Data bus for data from the CPRI v6.0 IP core to the external Ethernet block. All bits are de-asserted during reset, and all bits are asserted after reset until the CPRI v6.0 IP core achieves frame synchronization.   |
| TX MII Signals                       |           |   |
| Signal Name                          | Direction | Description   |
| <code>mii_txclk</code>               | Input     | Clocks the MII transmitter interface. You must drive this clock at the frequency of 25 MHz to achieve the 100 Mbps bandwidth required for this interface.   |
| <code>mii_txreset_n</code>           | Input     | Resets the MII transmitter interface and FIFO write logic. This signal is active low.   |
| <code>mii_txen</code>                | Input     | Valid signal from the external Ethernet block, indicating the presence of valid data on <code>mii_txd[3:0]</code> . The external Ethernet block must also assert this signal two cycles before initial valid data, while the IP core inserts /J/ and /K/ nibbles in the data stream to form the start-of-packet symbol. |
| <code>mii_txer</code>                | Input     | Ethernet transmit coding error. When this signal is asserted, the CPRI v6.0 IP core inserts an Ethernet HALT symbol in the data it passes to the CPRI link.   |
| <code>mii_txd[3:0]</code>            | Input     | Ethernet transmit nibble data. The data transmitted from the external Ethernet block to the CPRI v6.0 IP core, for transmission on the CPRI link. This input bus is synchronous to the rising edge of the <code>mii_txclk</code> clock.   |
| MII Status Signals                   |           |   |
| Signal Name                          | Direction | Description   |
| <code>mii_tx_fifo_status[3:0]</code> | Output    | Ethernet Tx PCS FIFO fill level status. The individual bits have the following meanings: <ul style="list-style-type: none"> <li>• Bit [3]: Empty</li> <li>• Bit [2]: Almost empty</li> <li>• Bit [1]: Full</li> <li>• Bit [0]: Almost full</li> </ul>   |

| MII Status Signals                   |           |   |
|--------------------------------------|-----------|---|
| Signal Name                          | Direction | Description   |
| <code>mii_rx_fifo_status[3:0]</code> | Output    | Ethernet Rx PCS FIFO fill level status. The individual bits have the following meanings: <ul style="list-style-type: none"> <li>• Bit [3]: Empty</li> <li>• Bit [2]: Almost empty</li> <li>• Bit [1]: Full</li> <li>• Bit [0]: Almost full</li> </ul> |

Figure 3-33: RX MII Timing Diagram

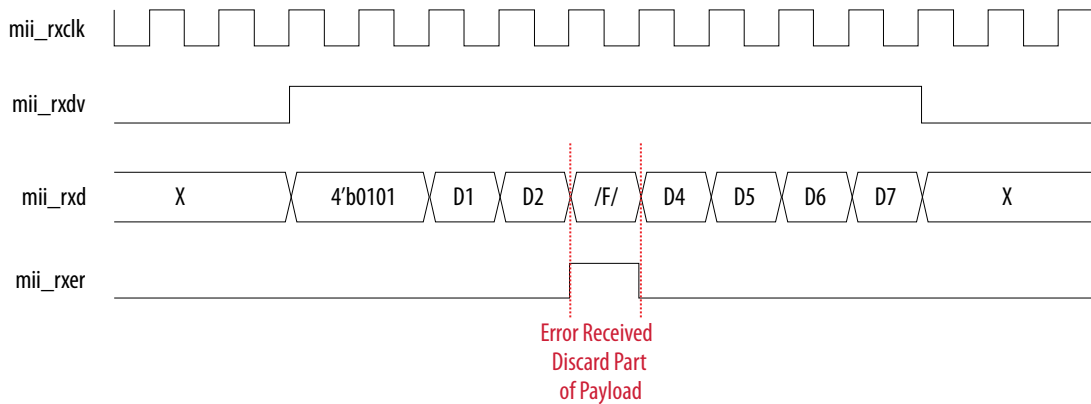
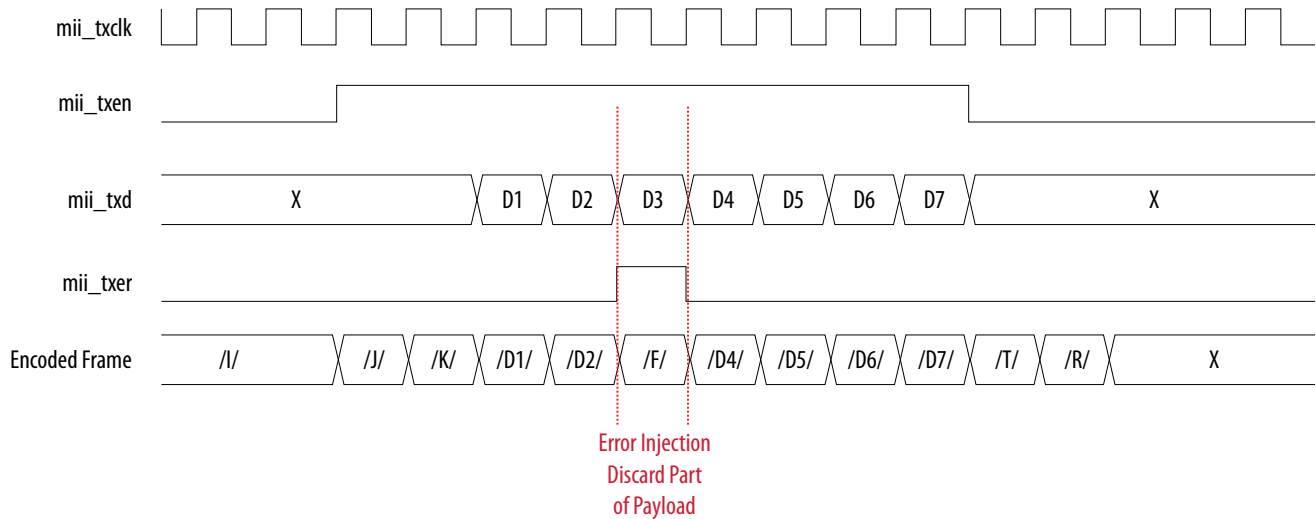


Figure 3-34: TX MII Timing Diagram

**Related Information**

[CPRI v6.0 IP Core L2 Interface](#) on page 4-1

## Gigabit Media Independent Interface (GMII) to External Ethernet Block

The gigabit media independent interface (GMII) allows the CPRI v6.0 IP core to communicate directly with an external Ethernet MAC block. If you set the value of the **Ethernet PCS interface** parameter in the CPRI v6.0 parameter editor to **GMII**, your IP core includes this interface.

The GMII supports the bandwidth described in the CPRI v6.0 Specification in Table 12, Achievable Ethernet bit rates.

**Table 3-14: GMII Signals**

These signals are available if you set the value of the **Ethernet PCS interface** parameter in the CPRI v6.0 parameter editor to **GMII**. You can connect a user-defined Ethernet MAC to this interface.

The interface is fully compliant to the IEEE 802.3 1000BASE-X 1Gbps MII specification. An Ethernet PCS block in the CPRI v6.0 IP core ensures the interface bandwidth matches the current CPRI line bit rate and accesses data at the correct CPRI frame positions according to the Z.194.0 pointer value.

You must monitor the GMII FIFO status signals and ensure you do not overflow or underflow the FIFO.

The interface signals are clocked by the `gmi_i_rxclk` or `gmi_i_txclk` clock.

| RX GMII Signals              |           |   |
|------------------------------|-----------|---|
| Signal Name                  | Direction | Description   |
| <code>gmi_i_rxclk</code>     | Input     | Clocks the GMII receiver interface. You must drive this clock at the frequency of 125 MHz.  |
| <code>gmi_i_rxreset_n</code> | Input     | Resets the GMII receiver interface and FIFO read logic. This reset signal is active low.  |
| <code>gmi_i_rxdv</code>      | Output    | Ethernet receive data valid. Indicates the presence of valid data or initial start-of-packet control character on <code>gmi_i_rxd[7:0]</code> .   |
| <code>gmi_i_rxer</code>      | Output    | Ethernet receive error. Indicates an error on <code>gmi_i_rxd</code> . When this signal is asserted, the value on <code>gmi_i_rxd[7:0]</code> is 0x0E.  |
| <code>gmi_i_rxd[7:0]</code>  | Output    | Ethernet receive data. Data bus for data from the CPRI v6.0 IP core to the external Ethernet block. All bits are deasserted during reset, and all bits are asserted after reset until the CPRI v6.0 IP core achieves frame synchronization. |
| TX GMII Signals              |           |   |
| Signal Name                  | Direction | Description   |
| <code>gmi_i_txclk</code>     | Input     | Clocks the GMII transmitter interface. You must drive this clock at the frequency of 125 MHz.   |
| <code>gmi_i_txreset_n</code> | Input     | Resets the GMII transmitter interface and FIFO write logic. This signal is active low.  |



| TX GMII Signals         |           |  |
|-------------------------|-----------|--|
| Signal Name             | Direction | Description  |
| gmii_txen               | Input     | Valid signal from the external Ethernet block, indicating the presence of valid data on gmii_txd[7:0]. This signal must be asserted two cycles before data is actually valid. This advance notice provides time for the CPRI v6.0 GMII transmitter block to insert an S character in the data stream to form the start-of-packet symbol.<br><br>Deasserting this signal triggers the IP core to insert T and R characters in the data stream to form the end-of-packet symbol. |
| gmii_txer               | Input     | Ethernet transmit coding error. When this signal is asserted, the CPRI v6.0 IP core inserts an Ethernet Error Propagation symbol /V/ in the data it passes to the CPRI link.   |
| gmii_txd[7:0]           | Input     | Ethernet transmit data. The data transmitted from the external Ethernet block to the CPRI v6.0 IP core, for transmission on the CPRI link. This input bus is synchronous to the rising edge of the gmii_txclk clock.   |
| MII Status Signals      |           |  |
| Signal Name             | Direction | Description  |
| gmii_txfifo_status[3:0] | Output    | Ethernet Tx PCS FIFO fill level status. The individual bits have the following meanings: <ul style="list-style-type: none"> <li>• Bit [3]: Empty</li> <li>• Bit [2]: Almost empty</li> <li>• Bit [1]: Full</li> <li>• Bit [0]: Almost full</li> </ul>  |
| gmii_rxfifo_status[3:0] | Output    | Ethernet Rx PCS FIFO fill level status. The individual bits have the following meanings: <ul style="list-style-type: none"> <li>• Bit [3]: Empty</li> <li>• Bit [2]: Almost empty</li> <li>• Bit [1]: Full</li> <li>• Bit [0]: Almost full</li> </ul>  |

Figure 3-35: RX GMII Timing Diagram

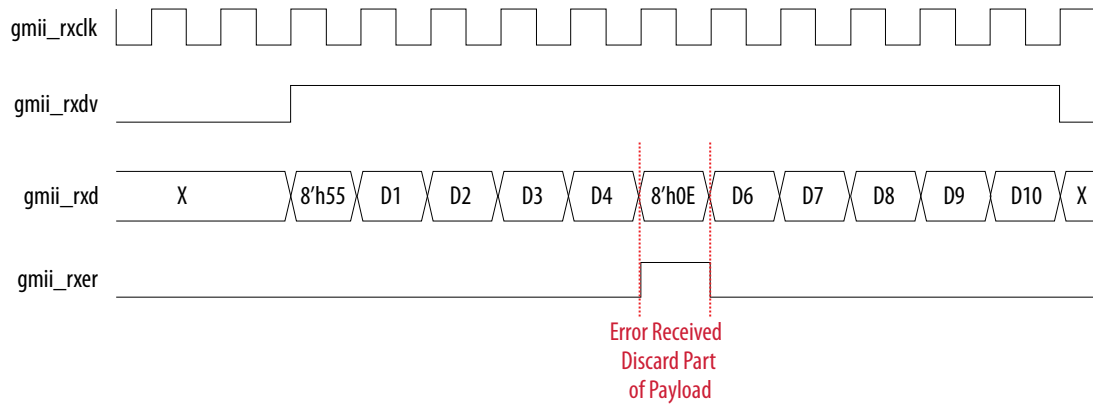
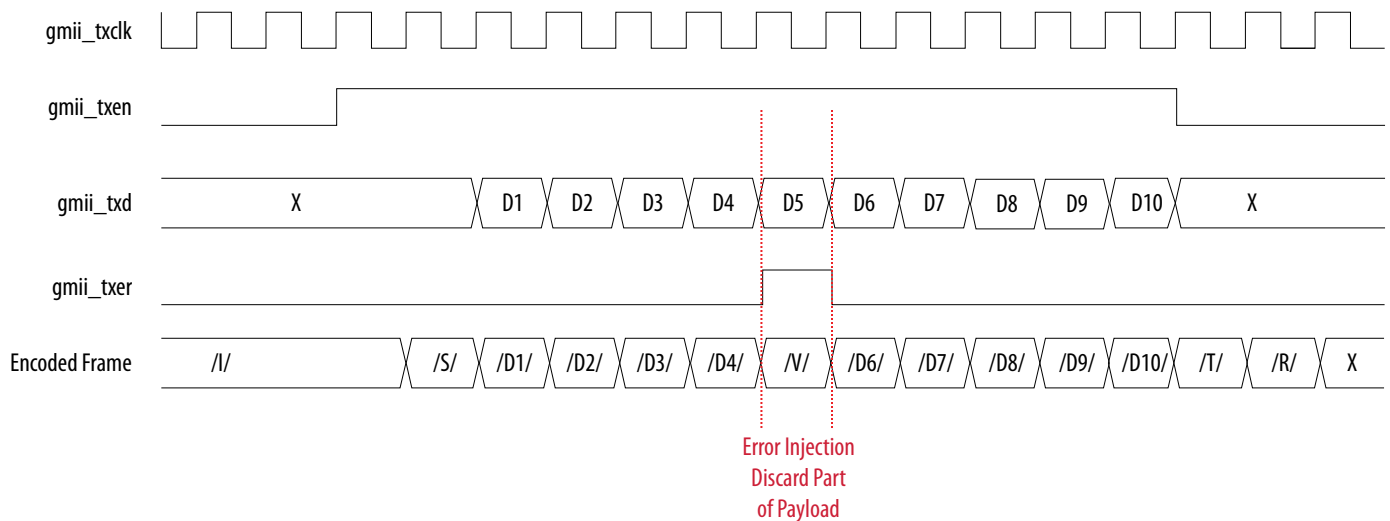


Figure 3-36: TX GMII Timing Diagram



**Related Information**

[CPRI v6.0 IP Core L2 Interface](#) on page 4-1

## CPU Interface to CPRI v6.0 IP Core Registers

Use the CPU interface to access the CPRI v6.0 IP core status and configuration registers. This interface does not provide access to the hard transceiver configuration registers on the Intel Arria 10 or Intel Stratix 10 device.

If you turn on **Enable all control word access via management interface** in the CPRI v6.0 parameter editor, you can access all CPRI hyperframe control words through this interface.

The control and status interface is an Avalon-MM slave interface. Depending on the value you specify for **Avalon-MM interface addressing type** in the CPRI v6.0 parameter editor, the interface implements word

addressing or byte addressing. If you specify word addressing, you must connect other design components correctly to the interface to ensure the Avalon-MM byte addresses appear on the CPRI v6.0 IP core CPU interface as word addresses.

An on-chip processor such as the Nios II processor, or an external processor, can access the CPRI v6.0 configuration address space using this Avalon-MM interface.

#### Related Information

#### [Avalon Interface Specifications](#)

For more information about the Avalon-MM protocol, including timing diagrams, refer to the *Avalon Memory-Mapped Interfaces* chapter.

## CPU Interface Signals

**Table 3-15: CPRI v6.0 IP Core CPU Interface Signals**

The CPRI v6.0 IP core CPU interface has the following features:

- Avalon-MM slave interface compliant.
- Provides support for single cycle read and write operations: you can read or write a single register in a single access operation.
- Supports a single `cpu_clk` clock cycle read latency and a zero `cpu_clk` clock cycle write latency for most registers.

| Signal Name                      | Direction | Description  |
|----------------------------------|-----------|--|
| <code>cpu_clk</code>             | Input     | Clocks the signals on the CPRI v6.0 CPU interface. Supports any frequency that the device fabric supports.   |
| <code>cpu_reset_n</code>         | Input     | Active low reset signal. Resets the CPRI v6.0 CPU interface and all of the registers to which it provides access.<br><br>You should hold this signal asserted for one full <code>cpu_clk</code> cycle to ensure it is captured by the IP core.   |
| <code>cpu_address[15:0]</code>   | Input     | Address for reads and writes. All CPRI v6.0 control and status registers are 32 bits wide. By default, this address is a word address (addresses a 4-byte (32-bit) word), not a byte address. However, if you set <b>Avalon-MM interface addressing type</b> to <b>Byte</b> in the CPRI v6.0 parameter editor, this address is a byte address. |
| <code>cpu_byteenable[3:0]</code> | Input     | Data-byte enable signal  |
| <code>cpu_read</code>            | Input     | You must assert this signal to request a read transfer   |
| <code>cpu_write</code>           | Input     | You must assert this signal to request a write transfer  |
| <code>cpu_writedata[31:0]</code> | Input     | Write data   |
| <code>cpu_readdata[31:0]</code>  | Output    | Read data  |

| Signal Name     | Direction | Description   |
|-----------------|-----------|---|
| cpu_waitrequest | Output    | Indicates that the control and status interface is busy executing an operation. When the IP core deasserts this signal, the operation is complete and the read data is valid.   |
| cpu_irq         | Output    | Interrupt request. All interrupts that you enable in the relevant register fields, assert this interrupt signal when they are triggered. You must check the relevant register fields to determine the cause or causes of the interrupt assertion. |

Figure 3-37: Read Transaction on CPU Interface

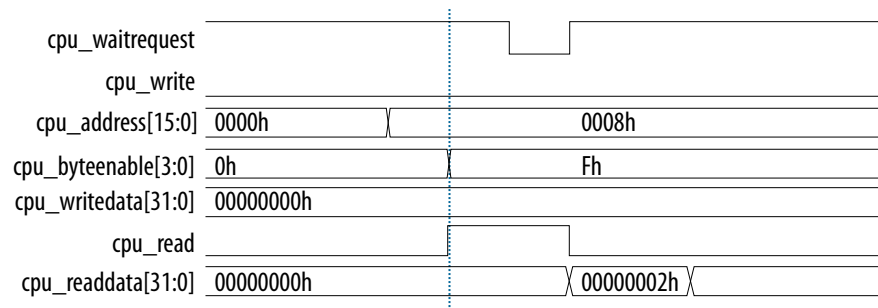
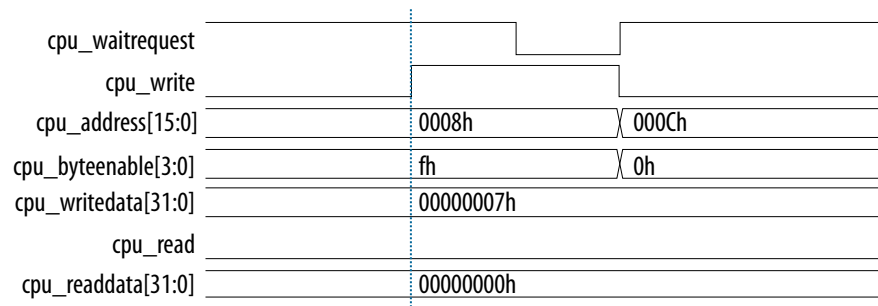


Figure 3-38: Write Transaction on CPU Interface



**Related Information**

**[Avalon Interface Specifications](#)**

For more information about the Avalon-MM protocol, refer to the *Avalon Memory-Mapped Interfaces* chapter.

**Accessing the Hyperframe Control Words**

When you turn on **Enable all control word access via management interface** in the CPRI v6.0 parameter editor, you can access the 256 control words in a hyperframe through the CPRI v6.0 IP core CPU interface. The `CTRL_INDEX` register and the `RX_CTRL` register support your application in reading the incoming control words, and the `L1_CONFIG` register, `CTRL_INDEX` register, and `TX_CTRL` register support the application in writing to outgoing control words.

Register support provides you access to the full control word. Alternatively, in timing-critical applications, you can access the full control words through the CPRI v6.0 IP core AUX interface or other dedicated direct interfaces.

**Note:** Intel recommends that you use the CPU interface to access the hyperframe control words only in applications that are not timing-critical.

## Specifying the Control Word

**Figure 3-39: Subchannels in a Hyperframe**

Illustrates how the 256 control words in the hyperframe are organized as 64 subchannels of four control words each. The figure illustrates why the index  $X$  of a control word is  $N_s + 64 + X_s$ , where  $N_s$  is the subchannel index and  $X_s$  is the index of the control word within the subchannel.

|                      | $X_s == 0$      | 1                          | 2               | 3                  |
|----------------------|-----------------|----------------------------|-----------------|--------------------|
| $N_s == 0$           | 0: K28.5        | Synchronization and Timing |                 |                    |
| 1                    | 1: HDLC link    | 65: HDLC                   | 129: HDLC       | 193: HDLC          |
| 2                    | 2: L1 In-band   | 66: L1 in-band             | 130: L1 in-band | 194: P (20 = 0x14) |
| 3                    | 3: Reserved     | 67: Reserved               |                 |                    |
| 4                    | 4: Ctrl_AxC     | ...                        | ...             | ...                |
| 7                    | 7: Ctrl_AxC     | 71: Ctrl_AxC               | 135: Ctrl_AxC   | 199: Ctrl_AxC      |
|                      | ...             |                            |                 |                    |
| 14                   | 14: Reserved    |                            |                 |                    |
| 15                   | 15: Reserved    | 79: Reserved               | 143: Reserved   | 207: Reserved      |
| 16                   | Vendor-specific |                            |                 |                    |
|                      | ...             |                            |                 |                    |
| 19                   |                 |                            |                 |                    |
| 20<br>Pointer P ---> | 20: Ethernet    |                            |                 |                    |
|                      | ...             |                            |                 |                    |
| 62                   | 62              | 126                        | 190             | 254                |
| 63                   | 63              | 127                        | 191             | 255                |

The `rx_ctrl_x` and `tx_ctrl_x` fields of the `CTRL_INDEX` register hold the  $X$  value of the control word you want to access through the control and status interface.

## Specifying the Position in the Control Word

You can access only 32 bits in a single register access. Depending on the CPRI line bit rate, a control word may have multiple 32-bit sections. Therefore, in addition to specifying the control word location in the CPRI frame, you must also specify a 32-bit aligned position in the control word.

**Table 3-16: Control Word Byte Positions in RX\_CTRL and TX\_CTRL Registers**

In this table, each control word nibble is indicated with 0xF. The presence of 0xF or 0x0 indicates whether the nibble within the register is populated with a valid control word nibble.

| CPRI Bit Rate (Gbps) | Register Access Sequence Number ({rx,tx}_ctrl_seq) |                   |                   |                   |                   |
|----------------------|--|-------------------|-------------------|-------------------|-------------------|
|                      | 0<br>(first access)                                | 1<br>(2nd access) | 2<br>(3rd access) | 3<br>(4th access) | 4<br>(5th access) |
| 0.6144               | FF000000   | 0                 | 0                 | 0                 | 0                 |
| 1.2288               | FFFF0000   | 0                 | 0                 | 0                 | 0                 |
| 2.4576               | FFFFFFFF   | 0                 | 0                 | 0                 | 0                 |
| 3.072                | FFFFFFFF   | FF000000          | 0                 | 0                 | 0                 |
| 4.9152               | FFFFFFFF   | FFFFFFFF          | 0                 | 0                 | 0                 |
| 6.144                | FFFFFFFF   | FFFFFFFF          | FFFF0000          | 0                 | 0                 |
| 8.11008, 9.8034      | FFFFFFFF   | FFFFFFFF          | FFFFFFFF          | FFFFFFFF          | 0                 |
| 10.1376              | FFFFFFFF   | FFFFFFFF          | FFFFFFFF          | FFFFFFFF          | FF000000          |

However, the table does not clarify which control word byte occupies which position in the register. The following examples indicate the correspondence between register bytes and control word bytes:

- At the CPRI line bit rate of 0.6144 Gbps, when you access hyperframe control word X, the 8-bit control word from hyperframe position #Z.X.0 is in bits [31:24] of the register.
- At the CPRI line bit rate of 1.2288 Gbps, the byte from position #Z.X.0.0 is in bits [31:24] of the register and the byte from position #Z.X.0.1 is in bits [23:16] of the register.
- At the CPRI line bit rate of 3.072 Gbps, you must access the register twice to retrieve or write the full control word. In the first access operation, you access the 32 bits of the control word in positions #Z.X.0.0 (in register bits [31:24]), #Z.X.0.1 (in register bits [23:16]), #Z.X.0.2 (in register bits [15:8]), and #Z.X.0.3 (in register bits [7:0]). In the second access operation, you access the eight bits of the control word in position #Z.X.0.4 in bits [31:24] of the register.

### Retrieving the Hyperframe Control Words

A control receive table contains one entry for each of the 256 control words in the current hyperframe. To read a control word, your application must write the control word number X to the `rx_ctrl_x` field of the `CTRL_INDEX` register and then read the last received #Z.X control word from the `RX_CTRL` register. Because the register can hold only 32 bits at a time, depending on the CPRI line bit rate, reading the full control word may require multiple register accesses. Increment the value in the `rx_ctrl_seq` field of the `CTRL_INDEX` register from zero to four to access the full control word when the CPRI line bit rate is 10.1376 Gbps, or from zero to two when the CPRI line bit rate is 6.144 Gbps, for example.

#### Example 3-1: Control Word Retrieval Example

To retrieve the vendor-specific portion of a control word in the most recent received hyperframe, perform the following steps:

1. Identify the indices for the vendor-specific portion of the transmit control table, using the formula  $X = N_s + 64 + X_s$ .

In the example,  $N_s = 16$  and  $X_s = 0, 1, 2,$  and  $3$ . Therefore, the indices to be read are 16, 80, 144, and 208.

2. For each value  $X$  in 16, 80, 144, and 208, perform the following steps:
  - a. Write the value  $X$  to the `rx_ctrl_x` field of the `CTRL_INDEX` register.
  - b. Reset the `rx_ctrl_seq` field of the `CTRL_INDEX` register to the value of zero.
  - c. In the following `cpu_clk` cycle, read the first 32-bit section of the control word from the `RX_CTRL` register.
  - d. If the CPRI line bit rate is greater than 2.4576 Gbps, increment the `rx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 1 and in the following `cpu_clk` cycle, read the second 32-bit section of the `#Z.X` control word from the `RX_CTRL` register.
  - e. If the CPRI line bit rate is greater than 4.9152 Gbps, increment the `rx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 2 and in the following `cpu_clk` cycle, read the third 32-bit section of the `#Z.X` control word from the `RX_CTRL` register.
  - f. If the CPRI line bit rate is greater than 6.144 Gbps, increment the `rx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 3 and in the following `cpu_clk` cycle, read the fourth 32-bit section of the `#Z.X` control word from the `RX_CTRL` register.
  - g. If the CPRI line bit rate is 10.1376 Gbps, increment the `rx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 4 and in the following `cpu_clk` cycle, read the fifth 32-bit section of the `#Z.X` control word (the real-time vendor specific bytes) from the `RX_CTRL` register.

## Writing the Hyperframe Control Words

A control transmit table contains one entry for each of the 256 control words in the current hyperframe. Each control transmit table entry contains a control word and an enable bit. As the frame is created, if a control word entry is enabled, and the global `tx_ctrl_insert_en` bit in the `L1_CONFIG` register is set, the IP core writes the appropriate control transmit table entry to the CPRI frame's control word.

You write to a control transmit table entry through the `TX_CTRL` register. This register access method requires that you write the control word in 32-bit sections. Use the `tx_ctrl_seq` field of the `CTRL_INDEX` register to specify the 32-bit section you are currently writing to the `TX_CTRL` register.

To write a control word in the control transmit table, perform the following steps:

1. Write the control word number  $X$  to the `tx_ctrl_x` field of the `CTRL_INDEX` register.
2. Reset the `tx_ctrl_seq` field of the `CTRL_INDEX` register to the value of zero.
3. Write the first 32-bit section of the next intended `#Z.X` control word to the `TX_CTRL` register.
4. If the CPRI line bit rate is greater than 2.4576 Gbps, increment the `tx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 1 and write the second 32-bit section of the next intended `#Z.X` control word to the `TX_CTRL` register.
5. If the CPRI line bit rate is greater than 4.9152 Gbps, increment the `tx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 2 and write the third 32-bit section of the next intended `#Z.X` control word to the `TX_CTRL` register.
6. If the CPRI line bit rate is greater than 6.144 Gbps, increment the `tx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 3 and write the fourth 32-bit section of the next intended `#Z.X` control word to the `TX_CTRL` register.

7. If the CPRI line bit rate is 10.1376 Gbps, increment the `tx_ctrl_seq` field of the `CTRL_INDEX` register to the value of 4 and write the fifth 32-bit section of the next intended #Z.X control word (the real-time vendor specific bytes) to the `TX_CTRL` register.
8. Set the `tx_ctrl_insert` bit of the `CTRL_INDEX` register to the value of 1.
9. After you update the control transmit table, set the `tx_ctrl_insert_en` bit of the `L1_CONFIG` register to enable the CPRI v6.0 IP core to write the values from the control transmit table to the control words in the outgoing CPRI frame.

The `tx_control_insert` bit of the `CTRL_INDEX` register enables or disables the transmission of the corresponding control transmit table entry in the CPRI frame. The `tx_ctrl_insert_en` bit of the `L1_CONFIG` register is the master enable: when it is set, the CPRI v6.0 IP core writes all table entries with the `tx_ctrl_insert` bit set into the CPRI frame.

### Example 3-2: Control Word Transmission Example

To write the vendor-specific portion of the control word in a transmitted hyperframe, perform the following steps:

1. Identify the indices for the vendor-specific portion of the transmit control table, using the formula  $X = N_s + 64 + X_s$ .

In the example,  $N_s = 16$  and  $X_s = 0, 1, 2,$  and  $3$ . Therefore, the indices to be read are 16, 80, 144, and 208.

2. For each value  $X$  in 16, 80, 144, and 208, perform the sequence of steps listed above.

After you update the control transmit table with the control bytes, to insert the data in the next outgoing CPRI frame, make sure that you set the `tx_ctrl_insert_en` bit of the `L1_CONFIG` register to the value of 1 as specified in the instructions.

## Auto-Rate Negotiation

If you turn on **Enable line bit rate auto-negotiation** in the CPRI v6.0 parameter editor, the auto-rate negotiation control and status interface is available. The CPRI v6.0 IP core provides support for dynamically changing the CPRI line bit rate, but requires that you implement user logic to control the auto-rate negotiation process. You control the process through the auto-rate negotiation control and status interface or the `BIT_RATE_CONFIG` register at offset 0x0C.

**Table 3-17: Auto-Rate Negotiation Control and Status Interface Signals**

All interface signals are clocked by the `cpri_clkout` clock.



| Signal Name           | Direction | Description  |
|-----------------------|-----------|--|
| nego_bitrate_in[4:0]  | Input     | <p>CPRI line bit rate to be used in next attempt to achieve frame synchronization, encoded according to the following valid values:</p> <ul style="list-style-type: none"> <li>• 5'b00001: 0.6144 Gbps</li> <li>• 5'b00010: 1.2288 Gbps</li> <li>• 5'b00100: 2.4576 Gbps</li> <li>• 5'b00101: 3.0720 Gbps</li> <li>• 5'b01000: 4.9150 Gbps</li> <li>• 5'b01010: 6.1440 Gbps</li> <li>• 5'b01100: 8.11008 Gbps</li> <li>• 5'b10000: 9.8304 Gbps</li> <li>• 5'b10100: 10.1376 Gbps</li> </ul> <p>This signal has higher priority than the <code>bit_rate</code> field in the <code>BIT_RATE_CONFIG</code> register at offset 0x0C. When this signal has the value of 5'b00000, the CPRI v6.0 IP core responds to the register field.</p> |
| nego_bitrate_out[4:0] | Output    | Reflects the current actual CPRI line bit rate.  |

#### Related Information

- [BIT\\_RATE\\_CONFIG Register](#) on page 5-5
- [Altera wiki CPRI v6.0 IP core information](#)  
Includes links to a reference design that implements auto-rate negotiation.

## Extended Delay Measurement

The CPRI v6.0 IP core employs an additional mechanism to measure the delay through the IP core FIFOs to your desired precision. Separate dedicated clocks support this measurement for the RX and TX internal buffers in all variations and for the hard FIFOs present only in Intel Stratix 10 variations.

#### Related Information

- [TX\\_EX\\_DELAY Register](#) on page 5-18
- [RX\\_EX\\_DELAY Register](#) on page 5-18
- [Extended Delay Measurement Interface](#) on page 3-59

## Extended Delay Measurement for Soft Internal Buffers

The CPRI v6.0 IP core uses a dedicated clock, `ex_delay_clk`, to measure the delay through the RX and TX internal buffers to your desired precision. The extended delay process is identical for the two directions of flow through the IP core; the `TX_EX_DELAY` and `RX_EX_DELAY` registers hold the same information for the two directions.

The `tx_msrm_period` field of the `TX_EX_DELAY` register contains the value  $N$ , such that  $N$  clock periods of the `ex_delay_clk` clock are equal to some whole number  $M$  of `cpri_clkout` periods. For example,  $N$  may be a multiple of  $M$ , or the  $M/N$  frequency ratio may be slightly greater than 1, such as 64/63 or 128/127.

The application layer specifies N to ensure the accuracy your application requires. The accuracy of the Tx buffer delay measurement is  $N/\text{least\_common\_multiple}(N,M)_{\text{cpri\_clkout}}$  periods.

Similarly, the `rx_msr_period` field of the `RX_EX_DELAY` register contains the value N, such that N clock periods of the `ex_delay_clk` clock are equal to some whole number M of `cpri_clkout` periods.

If your application does not require this precision, drive the `ex_delay_clk` input port with the `cpri_clkout` signal. In this case, the M/N ratio is 1 because the frequencies are the same.

The `tx_buf_delay` field of the `TX_DELAY` register indicates the number of 32-bit words currently in the Tx buffer. After you program the `tx_msr_period` field of the `TX_EX_DELAY` register with the value of N, the `tx_ex_delay` field of the `TX_EX_DELAY` register holds the current measured delay through the Tx buffer. The unit of measurement is `cpri_clkout` periods. The `tx_ex_delay_valid` field indicates that a new measurement has been written to the `tx_ex_delay` field since the previous register read. The following sections explain how you set and use these register values to derive the extended Tx delay measurement information.

### M/N Ratio Selection

As your selected M/N ratio approaches 1, the accuracy provided by the extended delay measurement increases.

**Table 3-18: Resolution as a Function of M/N Ratio at 3.072 Gbps**

| M   | N   | cpri_clkout Period     | ex_delay_clk Period | Resolution |
|-----|-----|------------------------|---------------------|------------|
| 128 | 127 | 13.02 ns (1/76.80 MHz) | 13.12 ns            | ±100 ps    |
| 64  | 63  |                        | 13.22 ns            | ±200 ps    |
| 1   | 4   |                        | 3.25 ns             | ±3.25 ns   |

### Example 3-3: Extended Delay Measurement Calculation Example

This section walks you through an example that shows you how to calculate the frequency at which to run `ex_delay_clk`, and how to program and use the registers to determine the delay through the CPRI Receive Buffer.

For example, assume your CPRI v6.0 IP core runs at CPRI line bit rate 3.072 Gbps. In this case, the `cpri_clkout` frequency is 76.80, so a `cpri_clkout` cycle is 1/76.80 MHz.

If your accuracy resolution requirements are satisfied by an M/N ratio of 128/127, perform the following steps:

1. Program the value N=127 in the `rx_msr_period` field of the `RX_EX_DELAY` register at offset 0x54.
2. Perform the following calculation to determine the `ex_delay_clk` frequency that supports your desired accuracy resolution:

$$\text{ex\_delay\_clk period} = (M/N)_{\text{cpri\_clkout period}} = (128/127)(1/(76.80 \text{ MHz})) = 13.123356 \text{ ns.}$$

Based on this calculation, the frequency of `ex_delay_clk` is  $1/(13.123356 \text{ ns})$

The following steps assume that you run `ex_delay_clk` at this frequency.

3. Read the value of the `RX_EX_DELAY` register at offset 0x54.

If the `rx_ex_delay_valid` field of the register is set to 1, the value in the `rx_ex_delay` field has been updated, and you can use it in the following calculations. For this example, assume the value read from the `rx_ex_delay` field is 0x107D, which is decimal 4221.

4. Perform the following calculation to determine the delay through the Rx buffer:

$$\text{Delay through Rx buffer} = (\text{rx\_ex\_delay} \times \text{cpri\_clkout period}) / N = (4221 \times 13.02083 \text{ ns}) / 127 = 432.7632 \text{ ns.}$$

This delay comprises  $(432.7632\text{ns} / 13.02083 \text{ ns}) = 33.236$  `cpri_clkout` clock cycles.

These numbers provide you the result for this particular example. For illustration, the preceding calculation shows the result in nanoseconds. You can derive the result in `cpri_clkout` clock cycles by dividing the preceding result by the `cpri_clkout` clock period. Alternatively, you can calculate the number of `cpri_clkout` clock cycles of delay through the Rx buffer directly, as `rx_msr_period/N`.

## Extended Delay Measurement for Intel Stratix 10 Hard FIFOs

The CPRI v6.0 IP core uses a dedicated clock, `latency_sclk`, to measure the delay through the RX and TX Intel Stratix 10 device hard FIFOs that are configured in the CPRI v6.0 IP core.

The delay calculation process is identical for the two directions of flow through the IP core; the `XCVR_TX_FIFO_DELAY` and `XCVR_RX_FIFO_DELAY` registers hold the same information for the two directions.

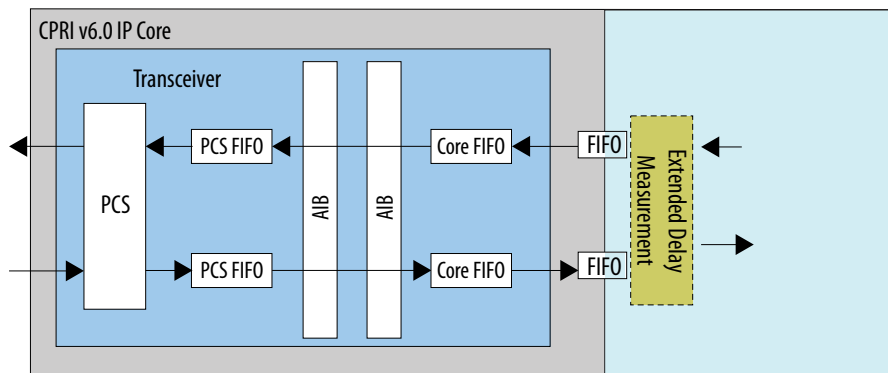
To measure the current Tx delay through the hard FIFOs:

- Check the `tx_pcs_fifo_delay_valid` and `tx_core_fifo_delay_valid` fields of the `XCVR_TX_FIFO_DELAY` register at offset 0x84 to ensure the delay count values are updated.
- Add the delay count values in the `tx_pcs_fifo_delay` and `tx_core_fifo_delay` fields of the `XCVR_TX_FIFO_DELAY` register at offset 0x84.
- Multiply the result by the clock period of the `latency_sclk`.
- Divide this result by 128.

To measure the current Rx delay through the hard FIFOs:

- Check the `rx_pcs_fifo_delay_valid` and `rx_core_fifo_delay_valid` fields of the `XCVR_RX_FIFO_DELAY` register at offset 0x88 to ensure the delay count values are updated.
- Add the delay count values in the `rx_pcs_fifo_delay` and `rx_core_fifo_delay` fields of the `XCVR_RX_FIFO_DELAY` register at offset 0x88.
- Multiply the result by the clock period of the `latency_sclk`.
- Divide this result by 128.

Figure 3-40: Additional Delay Through Stratix 10 Hard FIFOs



## Extended Delay Measurement Interface

Table 3-19: Extended Delay Measurement Interface Signals

| Signal Name      | Direction | Description  |
|------------------|-----------|--|
| ex_delay_clk     | Input     | Clock for extended delay measurement.  |
| ex_delay_reset_n | Input     | Resets the extended delay measurement block. This signal is active low.<br>This reset signal is associated with the ex_delay_clk clock.  |
| latency_sclk     | Input     | Clock for extended delay measurement of Intel Stratix 10 hard FIFOs.<br>You can (but need not) drive this clock at the same frequency as ex_delay_clk.                           |
| latency_sreset_n | Input     | Resets the extended delay measurement soft logic for the Intel Stratix 10 hard FIFOs. This signal is active low.<br>This reset signal is associated with the latency_sclk clock. |

## Deterministic Latency and Delay Measurement and Calibration

The CPRI v6.0 IP core complies with CPRI V6.0 Specification requirements R-19, R-20, R-20A, R-21, and R-21A.

## Delay Measurement and Calibration Features

The CPRI V6.0 Specification measurement and delay requirements support system configuration and correct synchronization.

The CPRI v6.0 IP core provides the following support for accurate delay measurement:

- Provides current Rx delay measurement values in the `RX_DELAY` and `RX_EX_DELAY` registers.
- Provides current Tx delay calibration values in the `XCVR_BITSLIP` register.
- Provides current round-trip delay measurement value in the `ROUND_TRIP_DELAY` register.
- Supports user control over delay measurement accuracy in the `TX_EX_DELAY` and `RX_EX_DELAY` registers.
- If you turn on **Enable round-trip delay calibration** in the CPRI v6.0 parameter editor, supports round-trip delay calibration.
- If you turn on **Enable single-trip delay calibration** in the CPRI v6.0 parameter editor, supports single-trip delay calibration.

## Delay Requirements

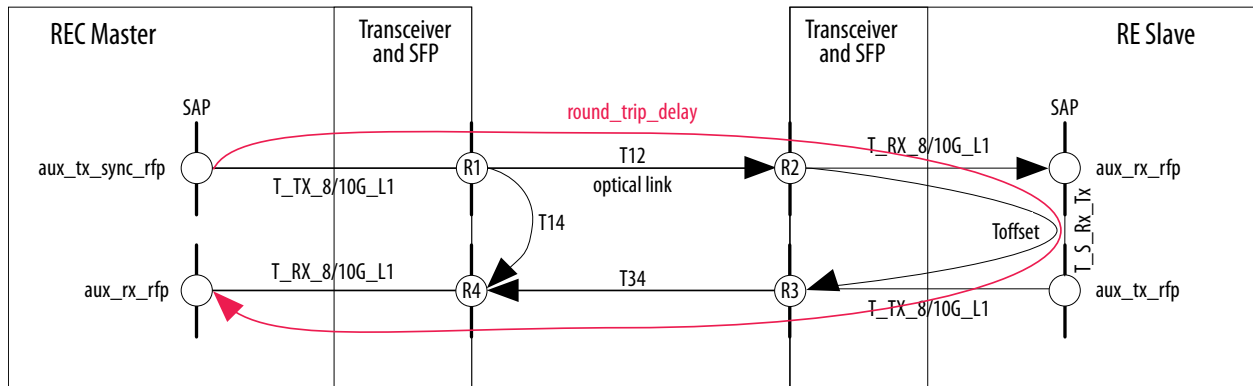
CPRI V6.0 Specification requirements R-17, R-18, and R-18A address jitter and frequency accuracy in the RE core clock for radio transmission. The relevant clock synchronization is performed using an external clean-up PLL that is not included in the CPRI v6.0 IP core.

CPRI V6.0 Specification requirement R-20A addresses the maximum allowed delay in switching between receiving and transmitting on the radio interface. The radio interface is implemented outside the IP core based on raw data presented on the AUX interface or other direct interfaces. Because the IP core provides duplex communication on these interfaces, no delay calculation is required.

Requirement R-19 specifies that the link delay accuracy for the downlink between the synchronization master SAP and the synchronization slave SAP, excluding the cable length, be within  $\pm 8.138$  ns. Requirements R-20 and R-21 extrapolate this requirement to single-hop round-trip delay accuracy. R-20 requires that the accuracy of the round-trip delay, excluding cables, be within  $\pm 16.276$  ns, and R-21 requires that the round-trip cable delay measurement accuracy be within the same range. Requirement R-21A extrapolates this requirement further, to multihop round-trip delay accuracy. In calculating these delays, Intel assumes that the downlink and uplink cable delays have the same duration.

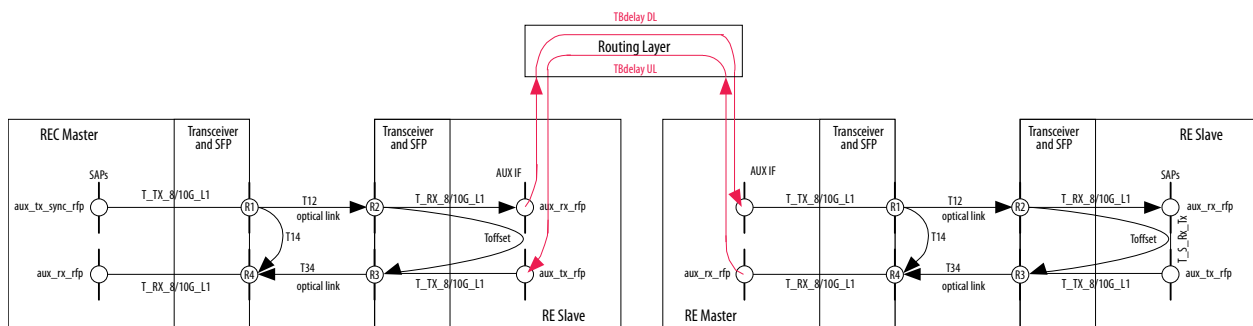
**Figure 3-41: Single-Hop CPRI v6.0 IP Core Configuration Delay Measurement Reference Points**

The round-trip cable delay is the sum of the T12 and T34 delays. The two delays are assumed to have the same duration.



**Figure 3-42: Multihop CPRI v6.0 IP Core Configuration Delay Measurement Reference Points**

The duration of TBdelay depends on your routing layer implementation.



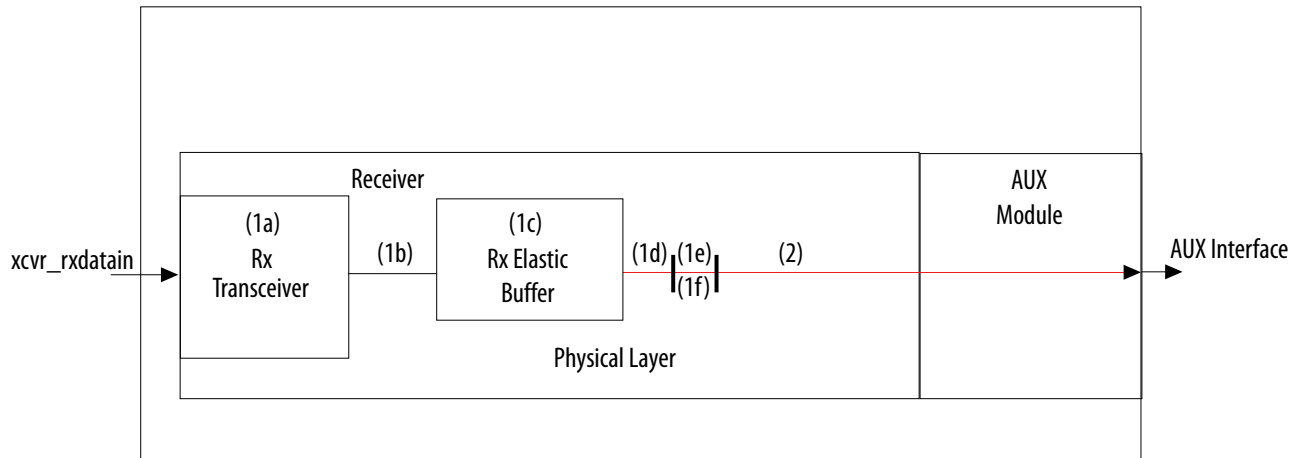
## Single-Hop Delay Measurement

The Rx path delay and Tx path delay through the CPRI v6.0 IP core are the main components of the round-trip delay through a single-hop system.

### Rx Path Delay

The Rx path delay is the cumulative delay from the arrival of the first bit of a 10 ms radio frame on the CPRI Rx interface to the start of transmission of the radio frame on the AUX interface.

Figure 3-43: Rx Path Delay to AUX Output in CPRI v6.0 IP Core



The Rx path delay to the AUX interface is the sum of the following delays:

1. The link delay is the delay between the arrival of the first bit of a 10 ms radio frame on the CPRI Rx interface and the CPRI v6.0 IP core internal transmission of the radio frame pulse from the CPRI protocol interface receiver.
  - a. Rx transceiver latency is a fixed delay through the deterministic latency path of the Rx transceiver. Its duration depends on the device family and the current CPRI line bit rate. This delay includes comma alignment and byte alignment within the transceiver.
  - b. Fixed delay from the Rx transceiver to the Rx elastic buffer. This delay depends on the device family and the CPRI line bit rate.
 

**Note:** In IP core variations that target an Intel Stratix 10 device, you must also add the delay through the Stratix 10 hard FIFOs in the Rx path.
  - c. Delay through the clock synchronization FIFO, as well as the phase difference between the recovered receive clock and the core clock `cpri_clkout`. The "Extended Delay Measurement" section shows how to calculate the delay in the CPRI v6.0 IP core Rx elastic buffer, which includes the phase difference delay.
  - d. Byte alignment delay that can occur as data is shifted out of the receiver. This variable delay appears in the `rx_byte_delay` field of the `RX_DELAY` register. When the value in `rx_byte_delay` is non-zero, a byte alignment delay of one `cpri_clkout` cycle occurs in the Rx path.
  - e. Variable delay introduced by the optional single-trip delay calibration feature in CPRI link slave IP cores.
  - f. Variable delay introduced by the optional round-trip delay calibration feature in CPRI link master IP cores.
2. Delay from the CPRI low-level receiver block to the AUX interface. This delay depends on the device family and the CPRI line bit rate.

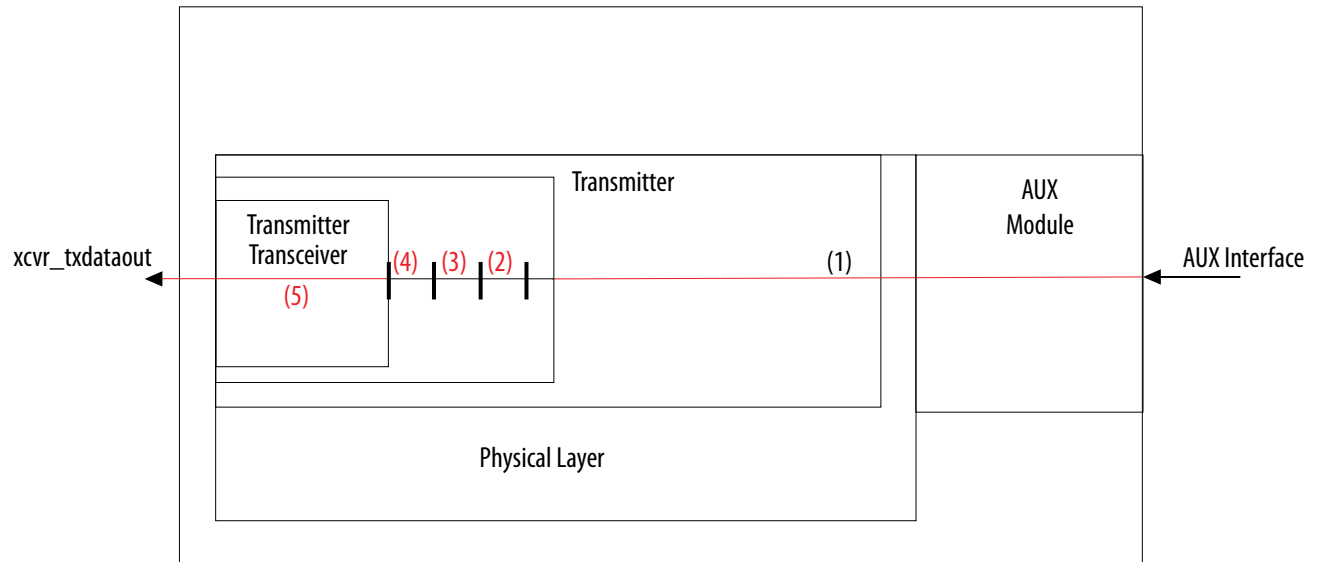
#### Related Information

[RX\\_DELAY Register](#) on page 5-17

### Tx Path Delay

The Tx path delay is the cumulative delay from the arrival of the first bit of a 10 ms radio frame on the CPRI AUX interface (or other direct interface) to the start of transmission of this data on the CPRI link.

Figure 3-44: Tx Path Delay from AUX Interface to CPRI Link in CPRI v6.0 IP Core



The Tx path delay from the AUX interface to the CPRI link is the sum of the following delays:

1. Fixed delay from the AUX interface through the CPRI low-level transmitter to the Tx elastic buffer. This delay depends on the device family and the current CPRI line bit rate.
2. Variable delay through the Tx elastic buffer, as well as the phase difference between the core clock `cpri_clkout` and the transceiver `tx_clkout` clock. The "Extended Delay Measurement" section shows how to calculate the delay in the CPRI v6.0 IP core Tx elastic buffer, which includes the phase difference delay.
3. Variable Tx bitslip delay in CPRI RE slaves. Refer to "Tx Bitslip Delay."
4. Fixed delay from the Tx elastic buffer to the transceiver. This delay depends on the device family and the CPRI line bit rate.

**Note:** In IP core variations that target an Intel Stratix 10 device, you must also add the delay through the Stratix 10 hard FIFOs in the Tx path. Refer to "Extended Delay Measurement for Intel Stratix 10 Hard FIFOs" section.

5. Link delay through the transceiver.

#### Related Information

[TX\\_DELAY Register](#) on page 5-16

### Round-Trip Delay

You can read the `ROUND_TRIP_DELAY` register or calculate the round-trip delay from the delay components (Rx path delay, Tx path delay, cable delay, and Rx-to-Tx switching latency). The `round_trip_delay` field of the `ROUND_TRIP_DELAY` register in an REC master records the total round-trip delay from the start of the internal transmit radio frame in the REC to the start of the internal receive radio frame in the REC, that is, from SAP to SAP, in CPRI REC and RE masters.

CPRI V6.0 Specification requirements R-20 and R-21 address the round-trip delay. Requirement R-20 addresses the measurement without including the cable delay, and requirement R-21 is the requirement for the cable delay. Both requirements state that the variation must be no more than  $\pm 16.276$  ns.



To monitor the round-trip delay, you must check periodically to confirm that the variation in measurements over time is small enough that the requirements are met.

**Note:** The round trip delay is the sum of the Tx path delays through the REC master and the RE slave, the Rx path delays through the REC master and the RE slave, the cable delay, and the Tx-to-Rx switching delay, sometimes referred to as the loopback delay. The Tx-to-Rx switching delay is labeled T\_S\_Rx\_Tx in the figure. The Tx-to-Rx switching delay depends on the loopback path and the device.

#### Related Information

[ROUND\\_TRIP\\_DELAY Register](#) on page 5-19

## Multi-Hop Delay Measurement

In a multi-hop system, you must combine the delays between and through the different CPRI masters and CPRI RE slaves to determine the round-trip delay.

To determine the round-trip delay of a full multi-hop system, you must add together the values in the ROUND\_TRIP\_DELAY registers of the REC and RE masters in the system, plus the delays through the external routers, and subtract the loopback delay from all the hops except the final hop.

$$\text{Round-trip delay} = \sum_i \text{round\_trip\_delay}(\text{hop } i) + \sum_j (\text{TBdelayUL} + \text{TBdelayDL})(j) - \sum_j \text{T\_S\_Rx\_Tx}(j)$$

where the REC and RE masters in the configuration are labeled  $i = 0, 1, \dots, n$  and the routing layers in the configuration, and their uplink and downlink delays, are labeled  $j = 0, 1, \dots, (n-1)$ .

As the equation shows, you must omit the loopback delay from the single-hop calculation for all but the final pair of CPRI link partners. The loopback delay is only relevant at the turnaround point of the full multi-hop path.

## Delay Calibration Features

The CPRI v6.0 IP core provides multiple calibration features to support compliance with the CPRI v6.0 Specification.

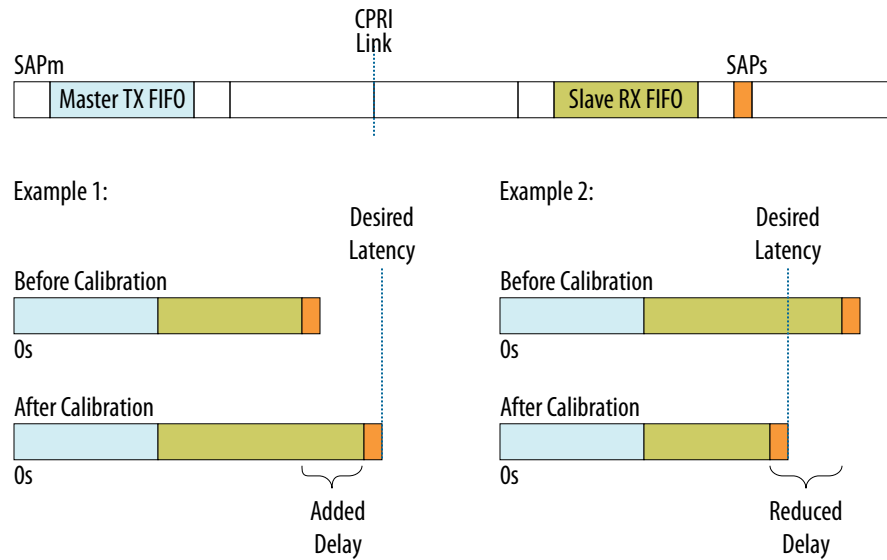
- If you turn on **Enable single-trip delay calibration** in the CPRI v6.0 parameter editor, supports single-trip delay calibration using the DELAY\_CAL\_STD\_CTRL1, DELAY\_CAL\_STD\_CTRL2, DELAY\_CAL\_STD\_CTRL3, DELAY\_CAL\_STD\_CTRL4, DELAY\_CAL\_STD\_CTRL5, and DELAY\_CAL\_STD\_STATUS registers. You can connect the IOPLL and DPCU blocks that Intel provides with the CPRI v6.0 IP core to ensure correct calibration results.
- If you turn on **Enable round-trip delay calibration** in the CPRI v6.0 parameter editor, supports round-trip delay calibration using the DELAY\_CAL\_RTD register.
- In all supported device families, increases the consistency of the round-trip delay using the XCVR\_BITSLIP register.

## Single-Trip Delay Calibration

The CPRI v6.0 IP core provides an optional mechanism to support calibrating the total delay through a CPRI master and slave on the downlink in a single hop.

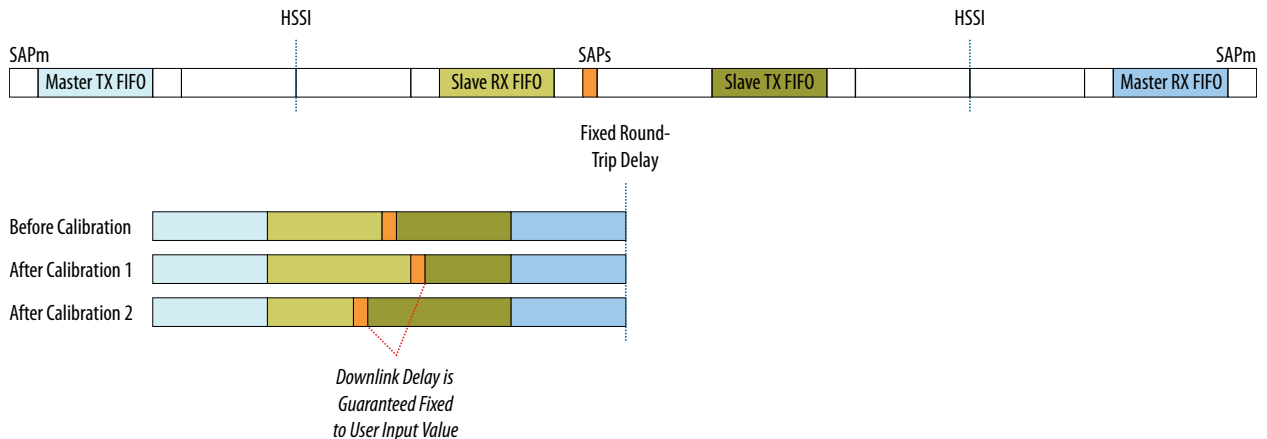
If you turn on **Enable single-trip delay calibration** in the CPRI v6.0 parameter editor, the CPRI v6.0 IP core and IOPLL and dynamic phase control unit (DPCU) blocks work together to adjust the delay through the RE slave Rx path in response to information about the delay through the REC or RE master Tx path.

Figure 3-45: Downlink Slave Delay Adjustment for Single-Trip Delay Calibration



The feature introduces the new delay to maintain a single-trip delay measurement as close as possible to the desired single-trip delay you provide to the CPRI v6.0 IP core. The application can also provide Tx path delay information that is appropriate for other use scenarios. For example, you might want to adjust the latency to the synchronization SAP to compensate for the IQ mapper requirements in your system. Refer to the Altera wiki Latency Formula and Calculation Example page.

Figure 3-46: Single-Trip Delay Does Not Affect Link Delay



The `cal_cycle_delay` and `cal_step_delay` fields of the `DELAY_CAL_STD_CTRL2` register in the CPRI link slave hold the anticipated delay that you program. The `cal_current_delay` field of the `DELAY_CAL_STD_STATUS` register in the CPRI link slave holds the total actual variable delay measurement in the single trip from the synchronization SAP in the CPRI link master to the synchronization SAP in the current CPRI link slave. You can manually specify a consistency check whenever you want, or you can specify that the IP core should run a consistency check once every hyperframe.

If you turn on single-trip delay calibration by setting the `cal_en` bit in the `DELAY_CAL_STD_CTRL1` register, the single-trip calibration feature is active. The user programs the `cal_cycle_delay` and `cal_step_delay` fields with the number of whole and fractional `cpri_clkout` cycles of single-trip variable delay that the system requires. After each consistency check, the CPRI v6.0 slave IP core adjusts the Rx delay to compensate for mismatches between the programmed, required single-trip delay and the actual single-trip variable delay recorded in the `cal_current_delay` register field. The delay adjustment mechanism is dynamic phase shifting of the `cpri_coreclk`.

The slave IP core requires the master IP core measured Tx delay information to calculate the `cal_current_delay` value. The master IP core sends this information to its downlink slave by one of two possible mechanisms. You program the master IP core `DELAY_CAL_STD4` register to specify whether the master sends this information in the incoming hyperframe (and at which location in the hyperframe) or the system writes it in the dedicated slave IP core `DELAY_CAL_STD_CTRL5` register. You program the slave IP core `DELAY_CAL_STD3` register to specify whether the slave receives this information in the incoming hyperframe (and at which location in the hyperframe) or the system writes it in the dedicated slave `DELAY_CAL_STD_CTRL5` register. If both CPRI master and slave are CPRI v6.0 IP cores, and the register values in the CPRI link master and slave do not match, the single-trip delay calibration does not function correctly. If the CPRI master is not a CPRI v6.0 IP core, the CPRI slave must receive the correct information in the programmed register or hyperframe location.

#### Related Information

##### [Altera wiki CPRI IP v6 Latency Formula and Calculation Example](#)

Provides information about how to use the single-trip delay calibration feature.

## Single-Trip Latency Measurement and Calibration Interface Signals

**Table 3-20: Single-Trip Latency Measurement and Calibration Interface Signals**

If you turn on **Enable single-trip delay calibration** in the CPRI v6.0 parameter editor, the single-trip latency measurement and calibration interface is available. This interface is designed to connect to the DPCU block that helps implement single-trip delay calibration.

All interface signals are clocked by the `reconfig_clk` clock.

| Signal Name                  | Direction | Description   |
|------------------------------|-----------|---|
| <code>cal_status[1:0]</code> | Input     | Status information from DPCU to CPRI v6.0 IP core.  |
| <code>cal_ctr1[15:0]</code>  | Output    | Control information from CPRI v6.0 IP core to DPCU. |

## Round-Trip Delay Calibration

If you turn on **Enable round-trip delay calibration** in the CPRI v6.0 parameter editor, the CPRI v6.0 IP core provides an additional, optional mechanism to help minimize the variation in the round-trip delay through a CPRI REC or RE master.

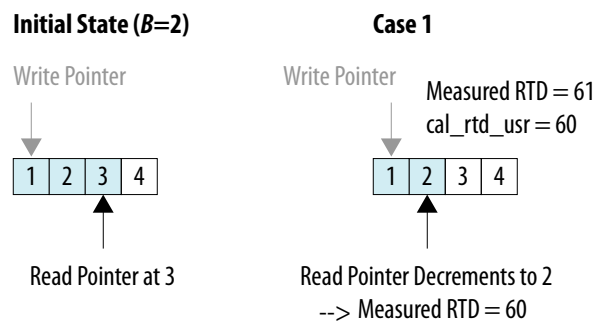
If you turn on **Enable round-trip delay calibration** in the CPRI v6.0 parameter editor, the dynamic pipelining feature for round-trip delay calibration introduces a delay in the Rx path in an REC or RE master. This delay is introduced to the Rx path immediately following the Rx elastic buffer. The feature introduces the new delay to maintain a round-trip delay measurement as close as possible to the anticipated round-trip delay you provide to the CPRI v6.0 IP core. The `DELAY_CAL_RTD` register holds the anticipated delay that you program, an enable bit you turn on to activate the feature, and a status field in which the CPRI v6.0 IP core reports its relative success in maintaining the round-trip delay you requested.

The CPRI v6.0 IP core is configured with a set of  $N=2^B$  pipelined registers in the Rx path, where  $B$  is the value you specified for **Round-trip delay calibration FIFO depth** in the parameter editor. If the two lowest order bits of the `cal_rtd_ctrl` field (bits [25:24] of the `DELAY_CAL_RTD` register) have the value of  $2'b01$ , the auto-calibration feature is active. The user programs the `cal_rtd_usr` field with the expected number of `cpri_clkout` cycles of round-trip delay. The CPRI v6.0 IP core adjusts the number of pipeline registers the data passes through (in contrast to the number of registers it bypasses) to compensate for mismatches between the desired round-trip delay programmed in the `cal_rtd_usr` field and the actual round-trip delay recorded in the `ROUND_TRIP_DELAY` register.

The `cal_rtd_status` field reports whether the CPRI IP core is successful in keeping the round-trip delay at the value you prescribed in the `cal_rtd_usr` field. If the two lowest order bits of the `cal_rtd_ctrl` field (bits [25:24] of the `DELAY_CAL_RTD` register) have the value of  $2'b01$ , the value of the `cal_rtd_status` field should remain at  $2'b10$ . If the value reaches  $2'b11$ , indicating that the IP core is unable to meet the calibration requirement, you should reset the link or restart the calibration. You might also need to re-instantiate the IP core with a larger number of pipeline registers to support additional adjustment.

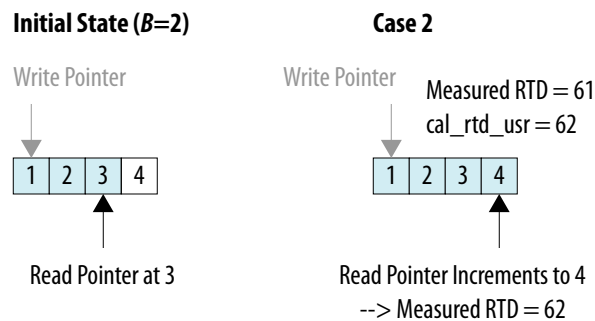
Initially, the number of pipeline registers the CPRI v6.0 IP core uses is one half the total number  $N$  of available register stages, plus one. This initial setting allows the IP core to adjust the number up or down as required, and adds  $(N/2)+1$  latency cycles to the RX path delay and the round-trip delay. For buffer depth  $N$ , the pipeline read pointer can move  $(N/2)-1$  entries in either direction from its initial state.

**Figure 3-47: Pipeline Read Pointer Decrements to Decrease Measured Round-Trip Delay**



In Case 1, the application writes the value of 60 in the `cal_rtd_usr` field of the `DELAY_CAL_RTD` register. When the CPRI v6.0 IP core measures the actual round-trip delay and sets the `round_trip_delay` field of the `ROUND_TRIP_DELAY` register to the value of 61, the CPRI v6.0 IP core responds by moving the read pointer to decrease the pipeline length, and therefore the measured round-trip delay value, by one `cpri_clkout` cycle. The adjustment achieves the desired effect: the measured round-trip delay value changes to 60.

**Figure 3-48: Pipeline Read Pointer Increments to Increase Measured Round-Trip Delay**



In Case 2, the application writes the value of 62 in the `cal_rtd_usr` field of the `DELAY_CAL_RTD` register. When the CPRI v6.0 IP core measures the actual round-trip delay and sets the `round_trip_delay` field of the `ROUND_TRIP_DELAY` register to the value of 61, the CPRI v6.0 IP core responds by moving the read pointer to increase the pipeline length, and therefore the measured round-trip delay value, by one `cpri_clkout` cycle. The adjustment achieves the desired effect: the measured round-trip delay value changes to 60.

## Tx Bitslip Delay

To increase the consistency of the round-trip delay, the CPRI v6.0 RE slave introduces a variable bitslip on the Tx path to complement the variability in the word aligner in the transceiver on the Rx path.

The CPRI v6.0 IP core reports the Rx bitslip through the word aligner in the `rx_bitslip_out` field of the `XCVR_BITSLIP` register, and compensates for the variable delay by adding a bitslip in the Tx path. The current size of this bitslip in bits is available in the `tx_bitslip_in` field of the `XCVR_BITSLIP` register. When you leave the `tx_bitslip_en` field at its default value of 0, this feature is active.

The Tx bitslip feature ensures stability in the round-trip delay through a CPRI v6.0 RE core, but introduces a variable component in each of the Tx and Rx paths when considered independently. In CPRI v6.0 IP cores in master clocking mode, the `rx_bitslip_out` field has the constant value of 0.

If you set the value of the `tx_bitslip_en` field to 1, you can override the current `rx_bitslip_out` value to control the Tx bitslip delay manually. Intel does not recommend implementing the manual override.

In CPRI v6.0 IP core variations that target an Arria V, Cyclone V, or Stratix V device, the Tx bitslip functionality is included in the Transceiver PHY IP core that is generated with the CPRI v6.0 IP core. These variations include the `XCVR_BITSLIP` register to support manual override of the Tx bitslip delay.

**Note:** Intel does not recommend implementing the manual override for the Tx bitslip.

The total of the Tx bitslip delay and the word aligner bitslip delay in the transceiver receiver is added to the detailed round-trip delay calculation as part of the Tx and Rx transceiver delays. However, the total of these two bit values does not reach the duration of a single `cpri_clkout` cycle, nor does it reach the threshold of the CPRI V6.0 specification R-20 and R-21 requirements. The bitslip delay is noticeable only with an oscilloscope.

### Related Information

[XCVR\\_BITSLIP Register](#) on page 5-19

## CPRI v6.0 IP Core Transceiver and Transceiver Management Interfaces

The CPRI v6.0 IP core configures the interface to the CPRI serial link in an Intel FPGA device transceiver channel. The IP core provides multiple interfaces for managing the transceiver. The transceiver is configured with a Native PHY IP core and exposes many of its optional interfaces for ease of IP core integration in your design.

## CPRI Link

The CPRI v6.0 IP core configures the interface to the CPRI serial link in an Intel FPGA device transceiver channel.

Table 3-21: CPRI Link Interface Signals

| Signal Name    | Direction | Description   |
|----------------|-----------|---|
| xcvr_rxdain    | Input     | High-speed serial data receiver port.   |
| xcvr_txdataout | Output    | High-speed serial data transmitter port.  |
| xcvr_los       | Input     | Asynchronous signal that forces link to LOS state for quick resynchronization.<br><br>If you implement the CPRI link with a fiber optic channel, you could connect this input signal to the SFP module LOS signal so that it is asserted when the SFP module loses signal. Otherwise, you should tie this signal to the value of 0. |

## Main Transceiver Clock and Reset Signals

Table 3-22: Main Transceiver Clock and Reset-Done Signals

The clocks for individual interfaces are listed with the relevant interface signals.

| Signal Name        | Direction | Description  |
|--------------------|-----------|--|
| xcvr_cdr_refclk    | Input     | Receiver CDR reference clock. You must drive this clock at the frequency you specified for the <b>Receiver CDR reference clock frequency (MHz)</b> parameter in the CPRI v6.0 parameter editor.  |
| xcvr_recovered_clk | Output    | Direct recovered clock from the receiver CDR. Use this output clock to drive the external clean-up PLL when your IP core is in slave mode. This clock is present only in CPRI v6.0 IP cores in slave clocking mode with <b>Operation mode</b> set to the value of <b>RX/TX Duplex</b> or <b>RX Simplex</b> . |
| xcvr_reset_tx_done | Output    | Indicates the transmitter and IP core Tx path have completed the internal reset sequence. This signal is clocked by the <code>cpri_clkout</code> clock.  |
| xcvr_reset_rx_done | Output    | Indicates the receiver and IP core Rx path have completed the internal reset sequence. This signal is clocked by the <code>cpri_clkout</code> clock.   |

| Signal Name        | Direction | Description   |
|--------------------|-----------|---|
| tx_analogreset_ack | Output    | <p>This signal rises after the TX analog reset process completes. This signal falls after you deassert the tx_analogreset signal. This signal is asynchronous. Refer to <i>Resetting Transceiver Channels</i> in the <i>Intel Arria 10 Transceiver PHY User Guide</i> or the appropriate Intel Stratix 10 Transceiver PHY user guide.</p> <p>This signal is available in CPRI v6.0 IP cores that target an Intel Arria 10 device or an Intel Stratix 10 device. Your custom auto-rate negotiation logic can monitor this signal to determine when it can safely begin reconfiguring the device transceiver to a new CPRI line bit rate.</p> |
| rx_analogreset_ack | Output    | <p>This signal rises after the RX analog reset process completes. This signal falls after you deassert the rx_analogreset signal. This signal is asynchronous. Refer to <i>Resetting Transceiver Channels</i> in the <i>Intel Arria 10 Transceiver PHY User Guide</i> or the appropriate Intel Stratix 10 Transceiver PHY user guide.</p> <p>This signal is available in CPRI v6.0 IP cores that target an Intel Arria 10 device or an Intel Stratix 10 device. Your custom auto-rate negotiation logic can monitor this signal to determine when it can safely begin reconfiguring the device transceiver to a new CPRI line bit rate.</p> |

#### Related Information

- [Resetting Transceiver Channels section of the Intel Arria 10 Transceiver PHY User Guide](#)  
Information about the tx\_analogreset\_ack and rx\_analogreset\_ack signals on Intel Arria 10 devices.
- [Resetting Transceiver Channels section of the Intel Stratix 10 GX 2800 L-Tile ES-1 Transceiver PHY User Guide](#)  
Information about the tx\_analogreset\_ack and rx\_analogreset\_ack signals on Intel Stratix 10 ES1 devices.
- [Resetting Transceiver Channels section of the Intel Stratix 10 L- and H-Tile Transceiver PHY User Guide](#)  
Information about the tx\_analogreset\_ack and rx\_analogreset\_ack signals on Intel Stratix 10 production devices.

## Arria V, Arria V GZ, Cyclone V, and Stratix V Transceiver Reconfiguration Interface

This interface is available only if you turn on at least one of these parameters in the CPRI v6.0 parameter editor:

- **Enable line bit rate auto-negotiation**
- **Enable start-up sequence state machine**

**Table 3-23: Arria V, Arria V GZ, Cyclone V, and Stratix V Transceiver Reconfiguration Interface Signals**

All interface signals are clocked by the reconfig\_clk clock.



| Signal Name              | Direction | Description  |
|--------------------------|-----------|--|
| reconfig_clk             | Input     | Clock for CPRI v6.0 IP core transceiver start-up and reconfiguration. The frequency range for this clock is 100–150 MHz.                     |
| reconfig_reset           | Input     | Asynchronous active-high reset signal for transceiver start-up and reconfiguration. Used for rate switching and auto-rate negotiation.       |
| reconfig_to_xcvr[69:0]   | Input     | Parallel transceiver reconfiguration bus from the Altera Transceiver Reconfiguration Controller to the transceiver in the CPRI v6.0 IP core. |
| reconfig_from_xcvr[45:0] | Output    | Parallel transceiver reconfiguration bus to the Altera Transceiver Reconfiguration Controller from the transceiver in the CPRI v6.0 IP core. |

#### Related Information

- [Adding the Transceiver Reconfiguration Controller](#) on page 2-22
- [Altera Transceiver PHY IP Core User Guide](#)  
Information about the Transceiver Reconfiguration Controller IP core.

## Intel Arria 10 and Intel Stratix 10 Transceiver Reconfiguration Interface

If you turn on certain parameters in the CPRI v6.0 parameter editor, Intel provides a dedicated Avalon-MM interface, called the transceiver reconfiguration interface, to access the Intel Arria 10 or Intel Stratix 10 transceiver registers. You access the Native PHY IP core registers through this dedicated interface and not through the IP core general purpose control and status interface. This interface provides access to the hard PCS registers on the device.

The Avalon-MM interface implements a standard memory-mapped protocol. You can connect an Avalon master to this bus to access the registers of the embedded Native PHY IP core.

This interface is available only in variations that target an Intel Arria 10 or Intel Stratix 10 device, and only if you turn on at least one of these parameters in the CPRI v6.0 parameter editor:

- **Enable line bit rate auto-negotiation**
- **Enable start-up sequence state machine**
- **Enable ADME, transceiver capability, control and status registers access**
- **Enable single-trip delay calibration**

**Table 3-24: CPRI v6.0 IP Core Transceiver Reconfiguration Interface Signals**

The `reconfig_clk` clocks the signals on the CPRI v6.0 IP core transceiver reconfiguration interface.

| Signal Name    | Direction | Description   |
|----------------|-----------|---|
| reconfig_clk   | Input     | Clocks the signals on the CPRI v6.0 transceiver reconfiguration interface. Supports frequency range 100–150 MHz.  |
| reconfig_reset | Input     | Asynchronous active-high reset signal. Resets the CPRI v6.0 transceiver reconfiguration interface and all of the registers to which it provides access. |



| Signal Name              | Direction | Description   |
|--------------------------|-----------|---|
| reconfig_write           | Input     | You must assert this signal to request a write transfer.  |
| reconfig_read            | Input     | You must assert this signal to request a read transfer.   |
| reconfig_address[9:0]    | Input     | Address for reads and writes.   |
| reconfig_writedata[31:0] | Input     | Write data.   |
| reconfig_readdata[31:0]  | Output    | Read data.  |
| reconfig_waitrequest     | Output    | The interface is busy. Do not issue Avalon-MM commands to this interface while this signal is high. |

Figure 3-49: Read Transaction on the Transceiver Reconfiguration Interface

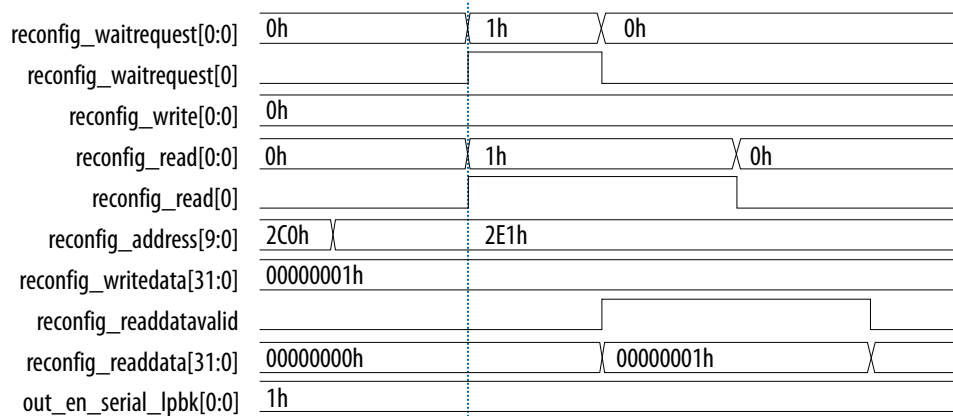
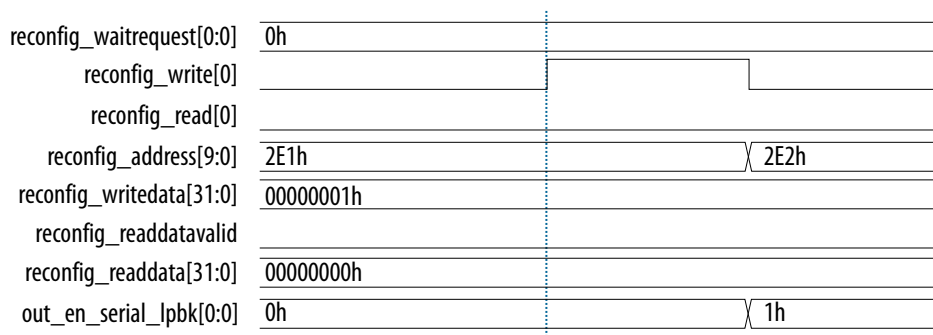


Figure 3-50: Write Transaction on the Transceiver Reconfiguration Interface



**Related Information**

- **Avalon Interface Specifications**  
For more information about the Avalon-MM protocol, refer to the *Avalon Memory-Mapped Interfaces* chapter.
- **Intel Arria 10 Transceiver PHY User Guide**  
Information about the Intel Arria 10 Native PHY IP core hard PCS registers that you can program through the transceiver reconfiguration interface.
- **Arria 10 Transceiver Registers**  
Detailed information about the Intel Arria 10 transceiver registers.
- **Intel Stratix 10 GX 2800 L-Tile ES-1 Transceiver PHY User Guide**  
Information about the Intel Stratix 10 Native PHY IP core hard PCS registers that you can program through the transceiver reconfiguration interface in your Intel Stratix 10 design that targets an Intel Stratix 10 ES1 device.
- **Intel Stratix 10 L- and H-Tile Transceiver PHY User Guide**  
Information about the Intel Stratix 10 Native PHY IP core hard PCS registers that you can program through the transceiver reconfiguration interface in your Intel Stratix 10 design that targets an Intel Stratix 10 production device.

## Interface to the External Reset Controller

**Table 3-25: CPRI v6.0 IP Core External Reset Controller Interface Signals**

The CPRI v6.0 IP core requires that you generate and connect at least one external transceiver reset controller.

| Signal Name                       | Direction | Description   |
|-----------------------------------|-----------|---|
| <code>xcvr_tx_analogreset</code>  | Input     | Analog reset to transmitter from external reset controller.   |
| <code>xcvr_tx_digitalreset</code> | Input     | Digital reset to transmitter from external reset controller.  |
| <code>xcvr_tx_cal_busy</code>     | Output    | Indicates to external reset controller that the transmitter is still busy with the calibration process.   |
| <code>xcvr_rx_analogreset</code>  | Input     | Analog reset to receiver from external reset controller.  |
| <code>xcvr_rx_digitalreset</code> | Input     | Digital reset to receiver from external reset controller.   |
| <code>xcvr_rx_cal_busy</code>     | Output    | Indicates to external reset controller that the receiver is still busy with the calibration process.  |
| <code>xcvr_reset_tx_ready</code>  | Input     | Indicates the Tx reset controller reset sequence is completed. When this signal is asserted, the IP core begins a reset of the IP core Tx path. |
| <code>xcvr_reset_rx_ready</code>  | Input     | Indicates the Rx reset controller reset sequence is completed. When this signal is asserted, the IP core begins a reset of the IP core Rx path. |

**Related Information**

- [Adding the Reset Controller](#) on page 2-20
- [Altera Transceiver PHY IP Core User Guide](#)  
Information about the Altera Transceiver Reset Controller IP core for 28-nm devices.
- [Intel Arria 10 Transceiver PHY User Guide](#)  
Information about the Transceiver Reset Controller IP core for Intel Arria 10 devices.
- [Intel Stratix 10 GX 2800 L-Tile ES-1 Transceiver PHY User Guide](#)  
Information about the Intel Stratix 10 Transceiver Reset Controller IP core for Intel Stratix 10 ES1 devices.
- [Intel Stratix 10 L- and H-Tile Transceiver PHY User Guide](#)  
Information about the Intel Stratix 10 Transceiver Reset Controller IP core for Intel Stratix 10 production devices.

## Interface to the External PLL

**Table 3-26: CPRI v6.0 IP Core External PLL Interface Signals**

The CPRI v6.0 IP core requires that you generate and connect an external transceiver PLL IP core.

| Signal Name                   | Direction | Description   |
|-------------------------------|-----------|---|
| <code>xcvr_ext_pll_clk</code> | Input     | <p>Clocks the transmitter PMA.</p> <p>You should drive this input clock with the output of the external transceiver TX PLL. In Arria 10 devices, you have a choice of different TX PLL IP cores to configure. You must ensure that you configure a PLL IP core that is capable of driving the frequency that the CPRI v6.0 IP core requires to run at the specified CPRI line bit rate.</p> |

**Related Information**

- [Adding the Transceiver TX PLL IP Core](#) on page 2-18
- [Altera Transceiver PHY IP Core User Guide](#)  
Information about the 28-nm device transceiver PLL IP cores.
- [Arria 10 Transceiver PHY User Guide](#)  
Information about the Arria 10 transceiver PLL IP cores.

## Transceiver Debug Interface

**Table 3-27: Transceiver Debug Interface Signals**

The CPRI v6.0 IP core provides a `xcvr_rx_is_lockedtodata` status signal. If you turn on **Enable L1 debug interfaces** in the CPRI v6.0 parameter editor, the IP core provides some additional status signals from the transceiver.

All of the transceiver debug signals are asynchronous.

| Signal Name                          | Direction | Description   |
|--------------------------------------|-----------|---|
| <code>xcvr_rx_is_lockedtodata</code> | Output    | Indicates that the receiver CDR is locked to the incoming serial data. This signal is available whether or not you turn on <b>Enable L1 debug interfaces</b> in the parameter editor. |
| <code>xcvr_rx_is_lockedtoref</code>  | Output    | Indicates that the receiver CDR is locked to the <code>xcvr_cdr_refclk</code> reference clock.  |
| <code>xcvr_rx_errdetect[3:0]</code>  | Output    | Each bit [n] indicates the receiver has detected an 8B/10B code group violation in byte [n] of the 32-bit data word.  |
| <code>xcvr_rx_disperr[3:0]</code>    | Output    | Each bit [n] indicates that the receiver has detected an 8B/10B parity error in byte [n] of the 32-bit data word.   |
| <code>xcvr_rx_blk_sh_err</code>      | Output    | Indicates that the receiver has detected a 64B/66B SYNC_HEADER violation.   |

## Testing Features

The CPRI v6.0 IP core supports multiple testing features.

### CPRI v6.0 IP Core Loopback Modes

Figure 3-51: CPRI v6.0 IP Core Loopback Modes

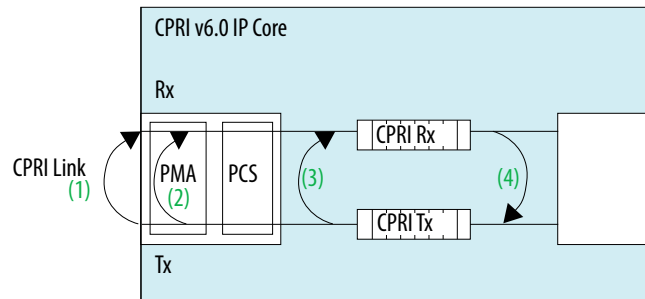


Table 3-28: Loopback Modes

| Tag in Figure | Description   | How to Configure   |
|---------------|---|--|
| 1             | External loopback: Use this configuration to test the full Tx and Rx paths from an application through the CPRI link and back to the application. | <p>Connect a CPRI REC master's CPRI Tx interface to its CPRI Rx interface by physically connecting the CPRI v6.0 IP core's high-speed transceiver output pins to its high-speed transceiver input pins.</p> <p>The connection medium must support the data rate requirements of the CPRI v6.0 IP core.</p> |

| Tag in Figure | Description  | How to Configure   |
|---------------|--|--|
| 2             | Transceiver PMA serial forward loopback path is active.          | Turn on <b>Enable transceiver PMA serial forward loopback path</b> in the parameter editor and set the <code>loop_forward</code> field of the <code>LOOPBACK</code> register to the value <code>2'b01</code> .   |
| 3             | Active parallel loopback path does not exercise the transceiver. | Turn on <b>Enable parallel forward loopback paths</b> in the parameter editor and set the <code>loop_forward</code> field of the <code>LOOPBACK</code> register to the value <code>2'b10</code> (to include the stitching logic to the transceiver) or <code>2'b11</code> (to exclude the stitching logic to the transceiver).                             |
| 4             | Reverse loopback path is active.                                 | Turn on <b>Enable parallel reversed loopback paths</b> in the parameter editor and set the <code>loop_reversed</code> field of the <code>LOOPBACK</code> register to a non-zero value. The register value specifies the parts of the CPRI frame that participate in the loopback path. Other parts of the CPRI frame are filled in from the local IP core. |

**Related Information**

[LOOPBACK Register](#) on page 5-15

**CPRI v6.0 IP Core Self-Synchronization Feature**

Intel provides a self-synchronization testing feature that supports an RE slave in a CPRI link external loopback configuration. This feature is intended to work correctly only for Layer 1 testing.

By default, only an REC master can function correctly in a CPRI link external loopback configuration. An RE slave in external loopback configuration cannot achieve frame synchronization, because the CPRI RX interface must lock on to the K28.5 character before the CPRI TX interface can begin sending K28.5 characters. Therefore, no K28.5 character is ever transmitted on the RE slave loopback CPRI link.

However, in an RE slave CPRI v6.0 IP core you can specify that the CPRI TX interface begin sending K28.5 characters before the CPRI Rx interface locks on to the K28.5 character from the CPRI link. This feature supports a CPRI RE slave in achieving frame synchronization without being connected to a CPRI master, and allows you to test your CPRI RE slave without the need for an additional CPRI v6.0 IP core.

To turn on this feature, connect your CPRI RE slave in a CPRI link external loopback configuration, and set the `tx_enable_force` field of the `L1_CONFIG` register to the value of 1.

**Related Information**

[L1\\_CONFIG Register](#) on page 5-5

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The CPRI v6.0 IP core communicates with the surrounding design through multiple external signals. Many of the signal interfaces are optional; their presence or absence depends on whether or not you enable the corresponding interface in the CPRI v6.0 parameter editor.

In the case of the interfaces that provide direct access to all or part of the CPRI frame, write transmit delay relative to the AUX TX interface synchronization signals depends on the **Auxiliary and direct interfaces write latency cycle(s)** parameter setting.

## CPRI v6.0 IP Core L2 Interface

The CPRI v6.0 IP core optionally communicates with an user-provided Ethernet MAC through the following signals.

**Table 4-1: MII and GMII Signals**

Each IP core has either MII signals, GMII signals, or neither.

| Signal Name   | Direction | Interface  |
|---------------|-----------|--|
| mii_rxclk     | Input     | RX MII signals<br><br>These signals are available only if you set the value of <b>Ethernet PCS interface to MII</b> in the CPRI v6.0 parameter editor. |
| mii_rxreset_n | Input     |  |
| mii_rxdv      | Output    |  |
| mii_rxer      | Output    |  |
| mii_rxd[3:0]  | Output    |  |
| mii_txclk     | Input     | TX MII signals<br><br>These signals are available only if you set the value of <b>Ethernet PCS interface to MII</b> in the CPRI v6.0 parameter editor. |
| mii_txreset_n | Input     |  |
| mii_txen      | Input     |  |
| mii_txer      | Input     |  |
| mii_txd[3:0]  | Input     |  |

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| Signal Name             | Direction | Interface  |
|-------------------------|-----------|--|
| mii_tx_fifo_status[3:0] | Output    | MII status signals   |
| mii_rx_fifo_status[3:0] | Output    | These signals are available only if you set the value of <b>Ethernet PCS interface to MII</b> in the CPRI v6.0 parameter editor.                         |
| gmii_rxclk              | Input     | RX GMII signals<br><br>These signals are available only if you set the value of <b>Ethernet PCS interface to GMII</b> in the CPRI v6.0 parameter editor. |
| gmii_rxreset_n          | Input     |  |
| gmii_rxdv               | Output    |  |
| gmii_rxer               | Output    |  |
| gmii_rxd[7:0]           | Output    |  |
| gmii_txclk              | Input     | TX GMII signals<br><br>These signals are available only if you set the value of <b>Ethernet PCS interface to GMII</b> in the CPRI v6.0 parameter editor. |
| gmii_txreset_n          | Input     |  |
| gmii_txen               | Input     |  |
| gmii_txer               | Input     |  |
| gmii_txd[7:0]           | Input     |  |
| gmii_txfifo_status[3:0] | Output    | GMII status signals  |
| gmii_rxfifo_status[3:0] | Output    | These signals are available only if you set the value of <b>Ethernet PCS interface to GMII</b> in the CPRI v6.0 parameter editor.                        |

#### Related Information

- [Media Independent Interface \(MII\) to External Ethernet Block](#) on page 3-44  
Describes the MII signals and provides MII timing diagrams.
- [Gigabit Media Independent Interface \(GMII\) to External Ethernet Block](#) on page 3-47

## CPRI v6.0 IP Core L1 Direct Access Interfaces

The CPRI v6.0 IP core can communicate with the surrounding design through multiple optional interfaces that provide direct access to all or part of the CPRI frame.

Table 4-2: L1 Direct Access Interface Signals

| Signal Name            | Direction | Description   |
|------------------------|-----------|---|
| aux_rx_rfp             | Output    | AUX RX interface status signals<br>These signals are available only if you turn on <b>Enable auxiliary interface</b> in the CPRI v6.0 parameter editor.             |
| aux_rx_hfp             | Output    |   |
| aux_rx_bfn[11:0]       | Output    |   |
| aux_rx_z[7:0]          | Output    |   |
| aux_rx_x[7:0]          | Output    |   |
| aux_rx_seq[6:0]        | Output    |   |
| aux_rx_data[31:0]      | Output    | AUX RX interface data signals   |
| aux_rx_ctrl[3:0]       | Output    | These signals are available only if you turn on <b>Enable auxiliary interface</b> in the CPRI v6.0 parameter editor.  |
| aux_tx_sync_rfp        | Input     | AUX TX interface control and status signals<br>These signals are available only if you turn on <b>Enable auxiliary interface</b> in the CPRI v6.0 parameter editor. |
| aux_tx_err[3:0]        | Output    |   |
| aux_tx_rfp             | Output    |   |
| aux_tx_hfp             | Output    |   |
| aux_tx_bfn[11:0]       | Output    |   |
| aux_tx_z[7:0]          | Output    |   |
| aux_tx_x[7:0]          | Output    |   |
| aux_tx_seq[6:0]        | Output    |   |
| aux_tx_data[31:0]      | Input     | AUX TX interface data signals   |
| aux_tx_mask[31:0]      | Input     | These signals are available only if you turn on <b>Enable auxiliary interface</b> in the CPRI v6.0 parameter editor.  |
| aux_tx_ctrl[3:0]       | Output    |   |
| iq_rx_valid[3:0]       | Output    |   |
| iq_rx_data[31:0]       | Output    | These signals are available only if you turn on <b>Enable direct IQ mapping interface</b> in the CPRI v6.0 parameter editor.  |
| iq_tx_ready[3:0]       | Output    | Direct IQ TX interface  |
| iq_tx_valid[3:0]       | Input     | These signals are available only if you turn on <b>Enable direct IQ mapping interface</b> in the CPRI v6.0 parameter editor.  |
| iq_tx_data[31:0]       | Input     |   |
| ctrl_axc_rx_valid[3:0] | Output    | Direct Ctrl_AxC RX interface  |
| ctrl_axc_rx_data[31:0] | Output    | These signals are available only if you turn on <b>Enable direct ctrl_axc access interface</b> in the CPRI v6.0 parameter editor.                                   |



| Signal Name            | Direction | Description   |
|------------------------|-----------|---|
| ctrl_axc_tx_ready[3:0] | Output    | Direct Ctrl_AxC TX interface  |
| ctrl_axc_tx_valid[3:0] | Input     | These signals are available only if you turn on <b>Enable direct ctrl_axc access interface</b> in the CPRI v6.0 parameter editor.           |
| ctrl_axc_tx_data[31:0] | Input     |   |
| vs_rx_valid[3:0]       | Output    | Direct VS RX interface  |
| vs_rx_data[31:0]       | Output    | These signals are available only if you turn on <b>Enable direct vendor specific access interface</b> in the CPRI v6.0 parameter editor.    |
| vs_tx_ready[3:0]       | Output    | Direct VS TX interface  |
| vs_tx_valid[3:0]       | Input     | These signals are available only if you turn on <b>Enable direct vendor specific access interface</b> in the CPRI v6.0 parameter editor.    |
| vs_tx_data[31:0]       | Input     |   |
| rtvs_rx_valid          | Output    | Direct RTVS RX interface  |
| rtvs_rx_data[31:0]     | Output    | These signals are available only if you turn on <b>Enable direct real-time vendor specific interface</b> in the CPRI v6.0 parameter editor. |
| rtvs_tx_ready          | Output    | Direct RTVS TX interface  |
| rtvs_tx_valid          | Input     | These signals are available only if you turn on <b>Enable direct real-time vendor specific interface</b> in the CPRI v6.0 parameter editor. |
| rtvs_tx_data[31:0]     | Input     |   |
| hdlc_rx_valid          | Output    | Direct HDLC serial RX interface   |
| hdlc_rx_data           | Output    | These signals are available only if you turn on <b>Enable HDLC serial interface</b> in the CPRI v6.0 parameter editor.                      |
| hdlc_tx_ready          | Output    | Direct HDLC serial TX interface   |
| hdlc_tx_valid          | Input     | These signals are available only if you turn on <b>Enable HDLC serial interface</b> in the CPRI v6.0 parameter editor.                      |
| hdlc_tx_data           | Input     |   |

| Signal Name       | Direction | Description   |
|-------------------|-----------|---|
| z130_local_lof    | Output    | Direct L1 control and status interface<br><br>These signals are available only if you turn on <b>Enable direct Z.130.0 alarm bits access interface</b> in the CPRI v6.0 parameter editor. |
| z130_local_los    | Output    |   |
| z130_sdi_assert   | Input     |   |
| z130_local_rai    | Output    |   |
| z130_reset_assert | Input     |   |
| z130_remote_lof   | Output    |   |
| z130_remote_los   | Output    |   |
| z130_sdi_req      | Output    |   |
| z130_remote_rai   | Output    |   |
| z130_reset_req    | Output    |   |

#### Related Information

- [AUX Interface](#) on page 3-18
- [AUX Interface Signals](#) on page 3-18
- [Direct IQ Interface](#) on page 3-30
- [Ctrl\\_AxC Interface](#) on page 3-32
- [Direct Vendor Specific Access Interface](#) on page 3-34
- [Real-Time Vendor Specific Interface](#) on page 3-36
- [Direct HDLC Serial Interface](#) on page 3-38
- [Direct L1 Control and Status Interface](#) on page 3-40

## CPRI v6.0 IP Core Management Interfaces

The CPRI v6.0 IP core provides multiple interfaces for managing the IP core and the properties of the CPRI link.

**Table 4-3: CPRI v6.0 IP Core Management Signals**

| Signal Name  | Direction | Description        |
|--------------|-----------|--------------------|
| cpri_clkout  | Output    | Main clock signals |
| cpri_coreclk | Input     |                    |
| tx_clkout    | Output    |                    |
| reset_n      | Input     | Main reset signals |
| reset_rx_n   | Input     |                    |
| reset_tx_n   | Input     |                    |

| Signal Name            | Direction | Description   |
|------------------------|-----------|---|
| cpu_clk                | Input     | CPU interface   |
| cpu_reset_n            | Input     |   |
| cpu_address[15:0]      | Input     |   |
| cpu_byteenable[3:0]    | Input     |   |
| cpu_read               | Input     |   |
| cpu_write              | Input     |   |
| cpu_writedata[31:0]    | Input     |   |
| cpu_readdata[31:0]     | Output    |   |
| cpu_waitrequest        | Output    |   |
| cpu_irq                | Output    |   |
| state_startup_seq[2:0] | Output    | Start-up sequence interface<br>With the exception of the <code>state_ll_synch</code> signal, these signals are available only if you turn on <b>Enable start-up sequence state machine</b> in the CPRI v6.0 parameter editor. |
| state_ll_synch[2:0]    | Output    |   |
| nego_bitrate_complete  | Input     |   |
| nego_protocol_complete | Input     |   |
| nego_cm_complete       | Input     |   |
| nego_vss_complete      | Input     |   |
| nego_ll_timer_expired  | Input     | Auto-rate negotiation control and status interface<br>These signals are available only if you turn on <b>Enable line bit rate auto-negotiation</b> in the CPRI v6.0 parameter editor.   |
| nego_bitrate_in[4:0]   | Input     |   |
| nego_bitrate_out[4:0]  | Output    | Extended delay measurement interface  |
| ex_delay_clk           | Input     |   |
| ex_delay_reset_n       | Input     |   |
| latency_sclk           | Input     |   |
| latency_sreset_n       | Input     | Extended delay measurement interface signals that are available only in IP core variations that target an Intel Stratix 10 device.  |

| Signal Name     | Direction | Description   |
|-----------------|-----------|---|
| cal_status[1:0] | Input     | Single-trip delay calibration interface   |
| cal_ctr1[15:0]  | Output    | This signals are available only if you turn on <b>Enable single-trip delay calibration</b> in the CPRI v6.0 parameter editor. |
| rx_lcv          | Output    | L1 debug interface  |
| rx_freq_alarm   | Output    | These signals are available only if you turn on <b>Enable L1 debug interfaces</b> in the CPRI v6.0 parameter editor.          |

#### Related Information

- [CPRI v6.0 IP Core Clocking Structure](#) on page 3-3
- [CPRI v6.0 IP Core Reset Requirements](#) on page 3-10
- [CPU Interface to CPRI v6.0 IP Core Registers](#) on page 3-49
- [CPU Interface Signals](#) on page 3-50
- [Start-Up Sequence Interface Signals](#) on page 3-15
- [Auto-Rate Negotiation](#) on page 3-55
- [Extended Delay Measurement](#) on page 3-56
- [Extended Delay Measurement Interface](#) on page 3-59
- [L1 Debug Interface](#) on page 3-44

## CPRI v6.0 IP Core Transceiver and Transceiver Management Signals

The CPRI v6.0 IP core configures the interface to the CPRI serial link in an Intel FPGA device transceiver channel. The IP core provides multiple interfaces for managing the transceiver. The transceiver is configured with a Native PHY IP core and exposes many of its optional interfaces for ease of IP core integration in your design.

**Table 4-4: Transceiver and Transceiver Management Signals**

| Signal Name        | Direction | Description  |
|--------------------|-----------|--|
| xcvr_cdr_refclk    | Input     | Main transceiver clock and reset-done signals<br><br>The tx_analogreset_ack and rx_analogreset_ack signals are available only in Intel Arria 10 and Intel Stratix 10 variations. |
| xcvr_recovered_clk | Output    |  |
| xcvr_reset_tx_done | Output    |  |
| xcvr_reset_rx_done | Output    |  |
| tx_analogreset_ack | Output    |  |
| rx_analogreset_ack | Output    |  |

| Signal Name              | Direction | Description  |
|--------------------------|-----------|--|
| xcvr_rxdatain            | Input     | CPRI link interface  |
| xcvr_txdataout           | Output    |  |
| xcvr_los                 | Input     |  |
| reconfig_clk             | Input     | 28-nm device transceiver reconfiguration interface   |
| reconfig_to_xcvr[69:0]   | Input     | These signals are present only in IP core variations that target an Arria V, Arria V GZ, Cyclone V, or Stratix V device. |
| reconfig_from_xcvr[45:0] | Output    |  |
| reconfig_clk             | Input     | Intel Arria 10 or Intel Stratix 10 transceiver reconfiguration interface   |
| reconfig_reset           | Input     |  |
| reconfig_write           | Input     |  |
| reconfig_read            | Input     |  |
| reconfig_address[9:0]    | Input     |  |
| reconfig_writedata[31:0] | Input     |  |
| reconfig_readdata[31:0]  | Output    |  |
| reconfig_waitrequest     | Output    | These signals are present only in IP core variations that target an Intel Arria 10 or Intel Stratix 10 device.           |

| Signal Name                              | Direction | Description   |
|--|-----------|---|
| xcvr_tx_analogreset                      | Input     | Interface to external reset controller  |
| xcvr_tx_digitalreset                     | Input     |   |
| xcvr_tx_cal_busy                         | Output    |   |
| xcvr_rx_analogreset                      | Input     |   |
| xcvr_rx_digitalreset                     | Input     |   |
| xcvr_rx_cal_busy                         | Output    |   |
| xcvr_reset_tx_ready                      | Input     |   |
| xcvr_reset_rx_ready                      | Input     |   |
| xcvr_rx_analogreset_stat                 | Input     |   |
| xcvr_rx_digitalreset_stat <sup>(2)</sup> | Input     |   |
| xcvr_rx_analogreset_stat <sup>(2)</sup>  | Input     |   |
| xcvr_tx_digitalreset_stat <sup>(2)</sup> | Input     |   |
| xcvr_ext_pll_clk                         | Input     | Interface to external TX PLL  |
| xcvr_rx_is_lockedtodata                  | Output    | Transceiver debug interface   |
| xcvr_rx_is_lockedtoref                   | Output    | Transceiver debug interface<br>These signals are present only if you turn on <b>Enable L1 debug interfaces</b> in the CPRI v6.0 parameter editor. |
| xcvr_rx_errdetect[3:0]                   | Output    |   |
| xcvr_rx_disperr[3:0]                     | Output    |   |
| xcvr_rx_blk_sh_err                       | Output    |   |

#### Related Information

- [Main Transceiver Clock and Reset Signals](#) on page 3-69
- [CPRI Link](#) on page 3-68
- [Arria V, Arria V GZ, Cyclone V, and Stratix V Transceiver Reconfiguration Interface](#) on page 3-70
- [Intel Arria 10 and Intel Stratix 10 Transceiver Reconfiguration Interface](#) on page 3-71
- [Interface to the External Reset Controller](#) on page 3-73
- [Interface to the External PLL](#) on page 3-74
- [Transceiver Debug Interface](#) on page 3-74

<sup>(2)</sup> These signals are present only in IP core variation that target an Intel Stratix 10 device.

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The CPRI v6.0 IP core internal registers are accessible using the CPU interface, an Avalon-MM interface which conforms to the *Avalon Interface Specifications*.

All of these registers are 32 bits wide and the addresses are shown as hexadecimal byte address values. The registers can be accessed on a 32-bit (4-byte) basis. The addressing for the registers therefore increments by units of 4.

Write access to a Reserved or undefined location has no effect. Read accesses to a Reserved or undefined location return an undefined result.

**Table 5-1: Register Access Codes**

Lists the access codes used to describe the type of register bits.

| Code | Description  |
|------|--|
| RW   | Read / write   |
| RO   | Read only  |
| RC   | Read to clear  |
| UR0  | Reserved —undefined result on read, no effect on write |

**Table 5-2: Control and Status Register Map**

| Offset | Register Name   | Function                            | Location of Additional Information                   |
|--------|-----------------|-------------------------------------|--|
| 0x00   | INTR            | Interrupt Control and Status        | <a href="#">INTR Register</a> on page 5-3            |
| 0x04   | L1_STATUS       | Layer 1 Status                      | <a href="#">L1_STATUS Register</a> on page 5-4       |
| 0x08   | L1_CONFIG       | Layer 1 Configuration               | <a href="#">L1_CONFIG Register</a> on page 5-5       |
| 0x0C   | BIT_RATE_CONFIG | Bit Rate Configuration              | <a href="#">BIT_RATE_CONFIG Register</a> on page 5-5 |
| 0x10   | PROT_VER        | Protocol Version Control and Status | <a href="#">PROT_VER Register</a> on page 5-6        |

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| Offset | Register Name       | Function  | Location of Additional Information                        |
|--------|---------------------|---|---|
| 0x14   | TX_SCR              | Transmitter Scrambler Control                                 | <a href="#">TX_SCR Register</a> on page 5-7               |
| 0x18   | RX_SCR              | Receiver Scrambler Status                                     | <a href="#">RX_SCR Register</a> on page 5-7               |
| 0x1C   | CM_CONFIG           | Layer 2 Control and Management Configuration                  | <a href="#">CM_CONFIG Register</a> on page 5-8            |
| 0x20   | CM_STATUS           | Layer 2 Control and Management Status                         | <a href="#">CM_STATUS Register</a> on page 5-9            |
| 0x24   | START_UP_SEQ        | Start-Up Sequence Control and Status                          | <a href="#">START_UP_SEQ Register</a> on page 5-9         |
| 0x28   | START_UP_TIMER      | Start-Up Sequence Timer Control                               | <a href="#">START_UP_TIMER Register</a> on page 5-11      |
| 0x2C   | FLSAR               | L1 Inband Z.130.0 Control and Status                          | <a href="#">FLSAR Register</a> on page 5-11               |
| 0x30   | CTRL_INDEX          | Control Word Index  | <a href="#">CTRL_INDEX Register</a> on page 5-12          |
| 0x34   | TX_CTRL             | Transmit Control Word   | <a href="#">TX_CTRL Register</a> on page 5-13             |
| 0x38   | RX_CTRL             | Receive Control Word  | <a href="#">RX_CTRL Register</a> on page 5-14             |
| 0x3C   | RX_ERR              | Receiver Error Status   | <a href="#">RX_ERR Register</a> on page 5-14              |
| 0x40   | RX_BFN              | Recovered Radio Frame Counter                                 | <a href="#">RX_BFN Register</a> on page 5-14              |
| 0x44   | LOOPBACK            | Loopback Control  | <a href="#">LOOPBACK Register</a> on page 5-15            |
| 0x48   | TX_DELAY            | Transmit Buffer Delay Control and Status                      | <a href="#">TX_DELAY Register</a> on page 5-16            |
| 0x4C   | RX_DELAY            | Receiver Buffer Delay Control and Status                      | <a href="#">RX_DELAY Register</a> on page 5-17            |
| 0x50   | TX_EX_DELAY         | Transmit Buffer Extended Delay Measurement Control and Status | <a href="#">TX_EX_DELAY Register</a> on page 5-18         |
| 0x54   | RX_EX_DELAY         | Receiver Buffer Extended Delay Measurement Status             | <a href="#">RX_EX_DELAY Register</a> on page 5-18         |
| 0x58   | ROUND_TRIP_DELAY    | Round Trip Delay  | <a href="#">ROUND_TRIP_DELAY Register</a> on page 5-19    |
| 0x5C   | XCVR_BITSLIP        | Transceiver Bit Slip Control and Status                       | <a href="#">XCVR_BITSLIP Register</a> on page 5-19        |
| 0x60   | DELAY_CAL_STD_CTRL1 | Single-Trip Delay Calibration Control 1                       | <a href="#">DELAY_CAL_STD_CTRL1 Register</a> on page 5-20 |



| Offset | Register Name        | Function  | Location of Additional Information                         |
|--------|----------------------|---|--|
| 0x64   | DELAY_CAL_STD_CTRL2  | Single-Trip Delay Calibration Control 2         | <a href="#">DELAY_CAL_STD_CTRL2 Register</a> on page 5-21  |
| 0x68   | DELAY_CAL_STD_CTRL3  | Single-Trip Delay Calibration Control 3         | <a href="#">DELAY_CAL_STD_CTRL3 Register</a> on page 5-22  |
| 0x6C   | DELAY_CAL_STD_CTRL4  | Single-Trip Delay Calibration Control 4         | <a href="#">DELAY_CAL_STD_CTRL4 Register</a> on page 5-22  |
| 0x70   | DELAY_CAL_STD_CTRL5  | Single-Trip Delay Calibration Control 5         | <a href="#">DELAY_CAL_STD_CTRL5 Register</a> on page 5-23  |
| 0x74   | DELAY_CAL_STD_STATUS | Single-Trip Delay Calibration Status            | <a href="#">DELAY_CAL_STD_STATUS Register</a> on page 5-24 |
| 0x80   | DELAY_CAL_RTD        | Round Trip Delay Calibration Control and Status | <a href="#">DELAY_CAL_RTD Register</a> on page 5-24        |
| 0x84   | XCVR_TX_FIFO_DELAY   | Intel Stratix 10 Transmitter FIFO Delay         | <a href="#">XCVR_TX_FIFO_DELAY Register</a> on page 5-25   |
| 0x88   | XCVR_RX_FIFO_DELAY   | Intel Stratix 10 Receiver FIFO Delay            | <a href="#">XCVR_RX_FIFO_DELAY Register</a> on page 5-26   |

## INTR Register

Table 5-3: CPRI v6.0 IP Core INTR Register at Offset 0x00

| Bits  | Field Name         | Type | Value on Reset | Description   |
|-------|--------------------|------|----------------|---|
| 31:19 | Reserved           | UR0  | 13'b0          |   |
| 18    | intr_sdi_pending   | RW   | 1'b0           | Indicates a remote SDI detected interrupt is not yet serviced                 |
| 17    | intr_rai_pending   | RW   | 1'b0           | Indicates a remote RAI detected interrupt is not yet serviced                 |
| 16    | intr_reset_pending | RW   | 1'b0           | Indicates a remote reset request or acknowledge interrupt is not yet serviced |
| 15:3  | Reserved           | UR0  | 13'b0          |   |
| 2     | intr_sdi_en        | RW   | 1'b0           | Z.130.0 remote SDI detected interrupt enable                                  |
| 1     | intr_rai_en        | RW   | 1'b0           | Z.130.0 remote RAI detected interrupt enable                                  |

| Bits | Field Name    | Type | Value on Reset | Description   |
|------|---------------|------|----------------|---|
| 0    | intr_reset_en | RW   | 1'b0           | Z.130.0 remote reset request or acknowledge received interrupt enable |

## L1\_STATUS Register

Table 5-4: CPRI v6.0 IP Core L1\_STATUS Register at Offset 0x04

| Bits  | Field Name         | Type | Value on Reset | Description   |
|-------|--------------------|------|----------------|---|
| 31:13 | Reserved           | UR0  | 19'b0          |   |
| 12    | rx_rfp_hold        | RC   | 1'b0           | Radio frame pulse received. This bit is asserted every 10 ms and remains asserted until cleared by user logic. <sup>(3)</sup>   |
| 11    | rx_freq_alarm_hold | RC   | 1'b0           | CPRI receive clock is not synchronous with main IP core clock (cpri_clkout). This alarm is asserted each time mismatches are found between the recovered CPRI receive clock and cpri_clkout, and remains asserted until cleared by user logic. <sup>(3)</sup><br><br>If you turn on <b>Enable L1 debug interfaces</b> in the CPRI v6.0 parameter editor, the original asynchronous pulse that sets this register field is visible on the rx_freq_alarm output signal. However, that signal is not available if you turn off <b>Enable L1 debug interfaces</b> . |
| 10    | rx_los_hold        | RC   | 1'b0           | Hold rx_los. <sup>(3)</sup>   |
| 9     | rx_err_hold        | RC   | 1'b0           | Hold rx_err. <sup>(3)</sup>   |
| 8     | rx_hfnsync_hold    | RC   | 1'b0           | Hold rx_hfnsync. <sup>(3)</sup>   |
| 7:3   | Reserved           | UR0  | 5'b0           |   |
| 2     | rx_los             | RC   | 1'b0           | Indicates receiver is in LOS state.   |
| 1     | rx_err             | RC   | 1'b0           | Indicates 8B10B LCV or 64B/66aB sync header violations detected.  |
| 0     | rx_hfnsync         | RC   | 1'b0           | Indicates receiver has achieved hyperframe synchronization state (HFNSYNC).   |

<sup>(3)</sup> This register field is a read-to-clear field. You must read the register twice to read the true value of the field after frame synchronization is achieved. If you observe this bit asserted during link initialization, read the register again after link initialization to confirm any errors.

## L1\_CONFIG Register

Table 5-5: CPRI v6.0 IP Core L1\_CONFIG Register at Offset 0x08

| Bits | Field Name           | Type | Value on Reset | Description   |
|------|----------------------|------|----------------|---|
| 31:4 | Reserved             | UR0  | 28'b0          |   |
| 3    | tx_ctrl_insert_en    | RW   | 1'b0           | Master enable for insertion of control transmit table entries in CPRI hyperframe. This signal enables control bytes for which the CTRL_INDEX register tx_control_insert bit is high to be written to the CPRI frame.  |
| 2    | tx_enable_force      | RW   | 1'b0           | Specifies whether the RE slave self-synchronization testing feature is activated. If the feature is activated, the CPRI RE slave attempts to achieve link synchronization without a CPRI link connection to a CPRI master.<br><br>Set this field to the value of 1 to enable the feature. The value of 1 is only valid if the CPRI IP core is configured as a CPRI slave. |
| 1    | synchronization_mode | RW   | <sup>(4)</sup> | Specifies whether the CPRI v6.0 IP core is configured as a CPRI slave or a CPRI master, according to the following values: <ul style="list-style-type: none"> <li>1'b0: The IP core is configured as a CPRI master.</li> <li>1'b1: The IP core is configured as a CPRI slave.</li> </ul>  |
| 0    | tx_enable            | RW   | 1'b0           | Enable transmission on CPRI link.   |

### Related Information

- [Writing the Hyperframe Control Words](#) on page 3-54
- [CPRI v6.0 IP Core Self-Synchronization Feature](#) on page 3-76

## BIT\_RATE\_CONFIG Register

Table 5-6: CPRI v6.0 IP Core BIT\_RATE\_CONFIG Register at Offset 0x0C

| Bits | Field Name | Type | Value on Reset | Description |
|------|------------|------|----------------|-------------|
| 31:5 | Reserved   | UR0  | 27'b0          |             |

<sup>(4)</sup> Reset value is the value you specify for **Synchronization mode** in the CPRI v6.0 parameter editor.

| Bits | Field Name | Type | Value on Reset | Description  |
|------|------------|------|----------------|--|
| 4:0  | bit_rate   | (5)  | (6)            | <p>CPRI line bit rate to be used in next attempt to achieve frame synchronization, encoded according to the following valid values:</p> <ul style="list-style-type: none"> <li>5'b00001: 0.6144 Gbps</li> <li>5'b00010: 1.2288 Gbps</li> <li>5'b00100: 2.4576 Gbps</li> <li>5'b00101: 3.0720 Gbps</li> <li>5'b01000: 4.9150 Gbps</li> <li>5'b01010: 6.1440 Gbps</li> <li>5'b01100: 8.11008 Gbps</li> <li>5'b10000: 9.8304 Gbps</li> <li>5'b10100: 10.1376 Gbps</li> </ul> <p>If the input signal <code>nego_bitrate_in</code> has a non-zero value, the CPRI v6.0 IP core uses the encoded value driven on <code>nego_bitrate_in</code> in the next attempt to achieve frame synchronization, and ignores the value in the <code>bit_rate</code> register field.</p> <p>The value driven on the <code>nego_bitrate_in</code> signal, if it is non-zero, always overrides the value in this register field.</p> |

**Related Information**

[Auto-Rate Negotiation](#) on page 3-55

## PROT\_VER Register

**Table 5-7: CPRI v6.0 IP Core PROT\_VER Register at Offset 0x10**

| Bits  | Field Name        | Type | Value on Reset | Description   |
|-------|-------------------|------|----------------|---|
| 31:25 | Reserved          | UR0  | 7'b0           |   |
| 24    | rx_prot_ver_valid | RO   | 1'b0           | Value received in incoming Z.2.0 control byte is a valid CPRI v6.0 protocol version encoding. |
| 23:16 | rx_prot_ver       | RO   | 8'b0           | Encoded protocol version received in incoming Z.2.0 control byte.                             |
| 15:10 | Reserved          | UR0  | 6'b0           |   |

(5) If you turn on **Enable line bit rate auto-negotiation**, this register field is a RW register field. If you turn off **Enable line bit rate auto-negotiation**, this register field is a RO register field.

(6) Reset value is the value you specify for **Line bit rate** in the CPRI v6.0 parameter editor.

| Bits | Field Name         | Type | Value on Reset | Description  |
|------|--------------------|------|----------------|--|
| 9    | prot_ver_auto      | RW   | 1'b1           | Enables auto negotiation of protocol version.  |
|      |                    | RO   | 1'b0           | If you turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> , this field is a RW register field with the default value of 1. Otherwise, this field is a RO register field with the default value of 0.  |
| 8    | rx_prot_ver_filter | RW   | 1'b1           | Enable filtering or protection of the Z.2.0 value across five consecutive hyperframes.   |
|      |                    | RO   | 1'b0           | If you turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> , this field is a RW register field with the default value of 1. Otherwise, this field is a RO register field with the default value of 0.  |
| 7:0  | tx_prot_ver        | RW   | 8'b01          | Transmit protocol version to be mapped to Z.2.0 to indicate whether or not the current hyperframe transmission is scrambled. The value 1 indicates it is not scrambled and the value 2 indicates it is scrambled.<br><br>If the prot_ver_auto field has the value of 1, the IP core automatically updates the tx_prot_ver field. |

## TX\_SCR Register

Table 5-8: CPRI v6.0 IP Core TX\_SCR Register at Offset 0x14

| Bits | Field Name  | Type | Value on Reset | Description   |
|------|-------------|------|----------------|---|
| 31   | Reserved    | UR0  | 1'b0           |   |
| 30:0 | tx_scr_seed | RW   | 31'b0          | Transmitter scrambler seed. If the seed has value 0, the transmission is not scrambled. |

## RX\_SCR Register

Table 5-9: CPRI v6.0 IP Core RX\_SCR Register at Offset 0x18

| Bits | Field Name    | Type | Value on Reset | Description   |
|------|---------------|------|----------------|---|
| 31   | rx_scr_active | RO   | 1'b0           | Indicates that the incoming hyperframe is scrambled. The value 1 indicates that the incoming communication is scrambled, and the value 0 indicates that it is not scrambled. The IP core determines whether or not the incoming communication is scrambled based on the protocol version. |
| 30:0 | rx_scr_seed   | RO   | 31'b0          | Received scrambler seed. The receiver descrambles the incoming CPRI communication based on this seed.   |

## CM\_CONFIG Register

Table 5-10: CPRI v6.0 IP Core CM\_CONFIG Register at Offset 0x1C

| Bits  | Field Name          | Type | Value on Reset | Description   |
|-------|---------------------|------|----------------|---|
| 31:13 | Reserved            | UR0  | 19'b0          |   |
| 12    | slow_cm_rate_auto   | RW   | 1'b1           | Enable auto-negotiation of HDLC rate.   |
|       |                     | RO   | 1'b0           | If you turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> , this field is a RW register field with the default value of 1. Otherwise, this field is a RO register field with the default value of 0. |
| 11    | slow_cm_rate_filter | RW   | 1'b1           | Enable filtering of HDLC rate.  |
| 10:8  | tx_slow_cm_rate     | RW   | 3'b110         | Rate configuration for slow Control and Management (HDLC). To be inserted in CPRI control byte Z.66.0.  |
| 7     | fast_cm_ptr_auto    | RW   | 1'b1           | Enable auto-negotiation of Ethernet rate.   |
|       |                     | RO   | 1'b0           | If you turn on <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b> , this field is a RW register field with the default value of 1. Otherwise, this field is a RO register field with the default value of 0. |
| 6     | fast_cm_ptr_filter  | RW   | 1'b1           | Enable filtering of Ethernet rate.  |
| 5:0   | tx_fast_cm_ptr      | RW   | 6'd20          | Pointer to first CPRI control word used for fast Control and Management (Ethernet). To be inserted in CPRI control byte Z.194.0.  |

## CM\_STATUS Register

Table 5-11: CPRI v6.0 IP Core CM\_STATUS Register at Offset 0x20

| Bits  | Field Name            | Type | Value on Reset | Description  |
|-------|-----------------------|------|----------------|--|
| 31:12 | Reserved              | UR0  | 20'b0          |  |
| 11    | rx_slow_cm_rate_valid | RO   | 1'b0           | Indicates that a valid HDLC rate has been accepted.  |
| 10:8  | rx_slow_cm_rate       | RO   | 3'b0           | Accepted received HDLC rate. The IP core receives this rate in the incoming Z.66.0 control byte.                             |
| 7     | Reserved              | UR0  | 1'b0           |  |
| 6     | rx_fast_cm_ptr_valid  | RO   | 1'b0           | Indicates that a valid Ethernet rate has been accepted. The IP core receives this rate in the incoming Z.194.0 control byte. |
| 5:0   | rx_fast_cm_ptr        | RO   | 6'b0           | Accepted received Ethernet rate.<br>Valid values are between 0x14 (decimal 20) and 0x3F (decimal 63), inclusive.             |

## START\_UP\_SEQ Register

Table 5-12: CPRI v6.0 IP Core START\_UP\_SEQ Register at Offset 0x24

This register is available only if you turn on **Enable start-up sequence state machine** in the CPRI v6.0 parameter editor.

| Bits  | Field Name            | Type | Value on Reset | Description  |
|-------|-----------------------|------|----------------|--|
| 31:17 | Reserved              | UR0  | 15'b0          |  |
| 16    | startup_timer_expired | RO   | 1'b0           | Indicates that the internal L1 start-up timer is expired, based on the value of the startup_timer_period field of the START_UP_TIMER register. |
| 15:11 | Reserved              | UR0  | 5'b0           |  |

| Bits | Field Name             | Type | Value on Reset | Description   |
|------|------------------------|------|----------------|---|
| 10:8 | state_startup_seq      | RO   | 3'b0           | <p>Indicates the current state of the start-up sequence. This field has the following valid values:</p> <ul style="list-style-type: none"> <li>3'b000: State A: Standby</li> <li>3'b001: State B: L1 Synchronization</li> <li>3'b011: State C: Protocol Setup</li> <li>3'b010: State D: Control and Management Setup</li> <li>3'b110: State E: Interface and VSS Negotiation</li> <li>3'b111: State F: Operation</li> <li>3'b101: State G: Passive Link</li> </ul>  |
| 7:4  | Reserved               | UR0  | 4'b0           |   |
| 3    | nego_vss_complete      | RW   | 1'b0           | <p>Indicates the Vendor Specific negotiation is complete. You must set this bit to move the start-up sequence state machine from state E to state F. If you turn on <b>Enable start-up sequence state machine</b>, the <code>nego_vss_complete</code> input signal writes directly to this register bit.</p>  |
| 2    | nego_cm_complete       | RW   | 1'b0           | <p>Indicates the Control and Management negotiation is complete and the start-up sequence state machine can move from state D to state E. If the <code>slow_cm_rate_auto</code> field or the <code>fast_cm_ptr_auto</code> field, or both, in the <code>CM_CONFIG</code> register has the value of 1, the IP core updates this bit if the user does not update it.</p> <p>If you turn on <b>Enable start-up sequence state machine</b>, the <code>nego_cm_complete</code> input signal writes directly to this register bit.</p> <p><b>Note:</b> If the Control and Management negotiation cannot complete successfully, per Figure 30 in the CPRI specification V6.0 (2013-08-30), the start-up sequence state machine moves from state D to state G. In that case the IP core does not set the <code>nego_cm_complete</code> bit, and the <code>state_startup_seq</code> field reflects the state change.</p> |
| 1    | nego_protocol_complete | RW   | 1'b0           | <p>Indicates the protocol version negotiation is complete and the start-up sequence state machine can move from state C to state D. If the <code>prot_ver_auto</code> field of the <code>PROT_VER</code> register has the value of 1, the IP core updates this bit if the user does not update it.</p> <p>If you turn on <b>Enable start-up sequence state machine</b>, the <code>nego_protocol_complete</code> input signal writes directly to this register bit.</p>  |



| Bits | Field Name            | Type | Value on Reset | Description  |
|------|-----------------------|------|----------------|--|
| 0    | nego_bitrate_complete | RW   | 1'b0           | Indicates the CPRI line bit rate negotiation is complete.<br><br>If you turn on <b>Enable start-up sequence state machine</b> , the nego_bitrate_complete input signal writes directly to this register bit. |

## START\_UP\_TIMER Register

**Table 5-13: CPRI v6.0 IP Core START\_UP\_TIMER Register at Offset 0x28**

This register is available only if you turn on **Enable start-up sequence state machine** in the CPRI v6.0 parameter editor.

| Bits      | Field Name           | Type | Value on Reset | Description   |
|-----------|----------------------|------|----------------|---|
| 31:<br>20 | Reserved             | UR0  | 12'b0          |   |
| 19:<br>0  | startup_timer_period | RW   | 20'b0          | Threshold value for L1 start-up timer to expire. The unit is cpri_coreclk clock cycles. |

## FLSAR Register

**Table 5-14: CPRI v6.0 IP Core FLSAR Register at Offset 0x2C**

The FLSAR register is the L1 inband control word Z.130.0 control and status register.

| Bits | Field Name   | Type | Value on Reset | Description   |
|------|--------------|------|----------------|---|
| 31   | Reserved     | UR0  | 1'b0           |   |
| 30   | local_lof    | RO   | 1'b0           | Local loss of frame (LOF) detected                                  |
| 29   | local_los    | RO   | 1'b0           | Local loss of signal (LOS) detected                                 |
| 28   | lof_detected | RO   | 1'b0           | Remote LOF detected   |
| 27   | los_detected | RO   | 1'b0           | Remote LOS detected   |
| 26   | sdi_detected | RO   | 1'b0           | Remote service access point (SAP) defect indication (SDI) detected. |

| Bits  | Field Name     | Type | Value on Reset | Description   |
|-------|----------------|------|----------------|---|
| 25    | rai_detected   | RO   | 1'b0           | Remote alarm indication (RAI) detected.   |
| 24    | reset_detected | RO   | 1'b0           | Reset request or acknowledgement detected.  |
| 23:17 | Reserved       | UR0  | 7'b0           |   |
| 16    | sdi_gen        | RW   | 1'b0           | Enable Z.130.0 SDI generation.  |
| 15:9  | Reserved       | UR0  | 7'b0           |   |
| 8     | rai_gen        | RW   | 1'b1           | Enable Z.130.0 RAI generation as a result of local loss of signal (LOS) or loss of frame (LOF). |
| 7:1   | Reserved       | UR0  | 7'b0           |   |
| 0     | reset_gen      | RW   | 1'b0           | Enable Z.130.0 reset generation.  |

**Related Information**

[Direct L1 Control and Status Interface](#) on page 3-40

## CTRL\_INDEX Register

**Table 5-15: CPRI v6.0 IP Core CTRL\_INDEX Register at Offset 0x30**

Frequency differences between the control and status interface clock `cpu_clk` and the main CPRI v6.0 IP core clock `cpri_clkout` might cause non-zero read latency and more than one clock cycle of write latency when accessing this register.

| Bits  | Field Name  | Type | Value on Reset | Description  |
|-------|-------------|------|----------------|--|
| 31:27 | Reserved    | UR0  | 5'b0           |  |
| 26:24 | rx_ctrl_seq | RW   | 3'b0           | Sequence number for CPRI control word 32-bit section monitoring. The value in this field determines the 32-bit section of the control receive table entry that appears in the <code>RX_CTRL</code> register. The value indicates whether this is the first, second, third, fourth, or fifth (for RTVS) 32-bit section in the control word. |
| 23:16 | rx_ctrl_x   | RW   | 8'b0           | Index for CPRI control word monitoring (X value in frame location #Z.X.Y). The value in this field determines the control receive table entry of which a 32-bit section appears in the <code>RX_CTRL</code> register.  |
| 15:12 | Reserved    | UR0  | 4'b0           |  |

| Bits | Field Name     | Type | Value on Reset | Description  |
|------|----------------|------|----------------|--|
| 11   | tx_ctrl_insert | RW   | 1'b0           | Control word 32-bit section transmit enable. This value is stored in the control transmit table with its associated entry. When you change the value of the tx_ctrl_seq field or the tx_ctrl_x field, the stored tx_ctrl_insert bit associated with the indexed entry appears in the tx_ctrl_insert field.<br><br>At the time the CPRI v6.0 IP core can insert a control transmit table entry in the associated position in the outgoing hyperframe on the CPRI link, if the tx_ctrl_insert bit associated with that entry has the value of 1, and the tx_ctrl_insert_en bit of the L1_CONFIG register is asserted, the IP core inserts the table entry in the hyperframe. |
| 10:8 | tx_ctrl_seq    | RW   | 3'b0           | Sequence number for CPRI control word 32-bit section insertion. The value in this field determines the 32-bit section of the control transmit table entry that appears in the TX_CTRL register. The value indicates whether this is the first, second, third, fourth, or fifth (for RTVS) 32-bit section in the control word.  |
| 7:0  | tx_ctrl_x      | RW   | 8'b0           | Index for CPRI control word insertion (X value in frame location #Z.X.Y). The value in this field determines the control transmit table entry of which a 32-bit section appears in the TX_CTRL register.   |

## TX\_CTRL Register

**Table 5-16: CPRI v6.0 IP Core TX\_CTRL Register at Offset 0x34**

Frequency differences between the control and status interface clock `cpu_clk` and the main CPRI v6.0 IP core clock `cpri_clkout` might cause non-zero read latency and more than one clock cycle of write latency when accessing this register.

| Bits | Field Name   | Type | Value on Reset | Description  |
|------|--------------|------|----------------|--|
| 31:0 | tx_ctrl_data | RW   | 32'b0          | CPRI control word 32-bit section to be transmitted in CPRI hyperframe position Z.x, where x is the index in the tx_ctrl_x field of the CTRL_INDEX register. The tx_ctrl_seq field of the CTRL_INDEX register indicates whether this is the first, second, third, fourth, or fifth such 32-bit section. |

## RX\_CTRL Register

**Table 5-17: CPRI v6.0 IP Core RX\_CTRL Register at Offset 0x38**

Frequency differences between the control and status interface clock `cpu_clk` and the main CPRI v6.0 IP core clock `cpri_clkout` might cause non-zero read latency and more than one clock cycle of write latency when accessing this register.

| Bits | Field Name                | Type | Value on Reset | Description   |
|------|---------------------------|------|----------------|---|
| 31:0 | <code>rx_ctrl_data</code> | RO   | 32'b0          | Most recent received CPRI control word 32-bit section from CPRI hyperframe position Z.x, where x is the index in the <code>rx_ctrl_x</code> field of the CTRL_INDEX register. The <code>rx_ctrl_seq</code> field of the CTRL_INDEX register indicates whether this is the first, second, third, fourth, or fifth such 32-bit section. |

## RX\_ERR Register

**Table 5-18: CPRI v6.0 IP Core RX\_ERR Register at Offset 0x3C**

| Bits  | Field Name          | Type | Value on Reset | Description   |
|-------|---------------------|------|----------------|---|
| 31:16 | Reserved            | UR0  | 16'b0          |   |
| 15:8  | <code>sh_err</code> | RC   | 8'b0           | Number of 64B/66B sync header violations detected in the transceiver. Enables CPRI link debugging. This register turns over to the value of 0 when it increments from the value of 255.   |
| 7:0   | <code>lcv</code>    | RC   | 8'b0           | Number of line code violations (LCVs) detected in the 8B/10B decoding block in the transceiver. Enables CPRI link debugging. This register turns over to the value of 0 when it increments from the value of 255.<br><br>This counter includes LCVs that occur during initialization. |

## RX\_BFN Register

**Table 5-19: CPRI v6.0 IP Core RX\_BFN Register at Offset 0x40**

| Bits  | Field Name       | Type | Value on Reset | Description         |
|-------|------------------|------|----------------|---------------------|
| 31:12 | Reserved         | UR0  | 20'b0          |                     |
| 11:0  | <code>bfm</code> | RO   | 12'b0          | Current BFN number. |

## LOOPBACK Register

Table 5-20: CPRI v6.0 IP Core LOOPBACK Register at Offset 0x44

| Bits  | Field Name    | Type | Value on Reset | Description   |
|-------|---------------|------|----------------|---|
| 31:11 | Reserved      | UR0  | 21'b0          |   |
| 10:8  | loop_reversed | RW   | 3'b0           | <p>Testing reverse loopback mode. If you turn on <b>Enable parallel reversed loopback paths</b> in the CPRI v6.0 parameter editor, this register field specifies the parts of the CPRI frame that are sent on the reverse loopback path. If you do not turn on this parameter, you should leave this register field at its default value of 3'b0.</p> <p>For standard testing, you would turn on these loopback modes in a CPRI RE slave only.</p> <p>This field has the following valid values:</p> <ul style="list-style-type: none"> <li>• 3'b000: No loopback.</li> <li>• 3'b001: Full CPRI frame loopback. Incoming CPR data and control words are sent back as-is in outgoing CPR communication.</li> <li>• 3'b010: I/Q data loopback. Incoming CPRI data are sent back in outgoing CPRI communication; control words are generated locally.</li> <li>• 3'b011: Fast control and management loopback. Incoming CPRI fast control and management (Ethernet) control and data words are sent back in outgoing CPRI communication; remaining data and control words are generated locally.</li> <li>• 3'b100: Fast control and management and VS loopback. Incoming CPRI fast control and management (Ethernet) and vendor-specific control words are sent back in outgoing CPRI communication; data and remaining control words are generated locally.</li> </ul> |
| 7:2   | Reserved      | UR0  | 6'b0           |   |

| Bits | Field Name       | Type | Value on Reset | Description  |
|------|------------------|------|----------------|--|
| 1:0  | loop_<br>forward | RW   | 2'b0           | <p>Testing forward loopback mode. If you turn on <b>Enable transceiver PMA serial forward loopback path</b> or <b>Enable parallel forward loopback paths</b> in the CPRI v6.0 parameter editor, this register field specifies the loopback path that is currently active. If you do not turn on either of these parameters, you should leave this register field at its default value of 2'b0.</p> <p>This field has the following valid values:</p> <ul style="list-style-type: none"> <li>• 2'b00: No loopback.</li> <li>• 2'b01: Transceiver PMA loopback path is active. This path does not exercise the transceiver PCS. This option is available only if you turn on <b>Enable transceiver PMA serial forward loopback path</b>.</li> <li>• 2'b10: Active loopback path includes extended delay measurement logic but does not exercise the transceiver. This option is available only if you turn on <b>Enable parallel forward loopback paths</b>.</li> <li>• 2'b11: Active loopback path includes framing and deframing logic, but does not exercise the extended delay measurement logic and does not exercise the transceiver. This option is available only if you turn on <b>Enable parallel forward loopback paths</b>.</li> </ul> |

**Related Information**

[CPRI v6.0 IP Core Loopback Modes](#) on page 3-75

## TX\_DELAY Register

Table 5-21: CPRI v6.0 IP Core TX\_DELAY Register at Offset 0x48

| Bits | Field Name | Type | Value on Reset | Description |
|------|------------|------|----------------|-------------|
| 31:9 | Reserved   | UR0  | 23'b0          |             |

| Bits | Field Name    | Type | Value on Reset | Description   |
|------|---------------|------|----------------|---|
| 8    | tx_buf_resync | RW   | 1'b0           | Force transmit buffer pointer resynchronization. You can use this register field to resynchronize if, for example, the buffer fill level becomes too high due to environmental impacts on the device, such as temperature. Resynchronizing might lead to data loss or corruption.<br><br>Do not use this register field to resynchronize after a dynamic CPRI line bit rate change. After a dynamic CPRI line bit rate change the IP core forces resynchronization internally without referring to this register. |
| 7:4  | Reserved      | UR0  | 4'b0           |   |
| 3:0  | tx_buf_delay  | RO   | 4'b0           | Current transmit buffer fill level.   |

**Related Information**[Tx Path Delay](#) on page 3-62

## RX\_DELAY Register

**Table 5-22: CPRI v6.0 IP Core RX\_DELAY Register at Offset 0x4C**

| Bits            | Field Name    | Type | Value on Reset | Description  |
|-----------------|---------------|------|----------------|--|
| 31:25           | Reserved      | UR0  | 7'b0           |  |
| 24              | rx_buf_resync | RW   | 1'b0           | Force receive buffer pointer resynchronization. You can use this register field to resynchronize if, for example, the buffer fill level becomes too high due to environmental impacts on the device, such as temperature. Resynchronizing might lead to data loss or corruption.<br><br>Do not use this register field to resynchronize after a dynamic CPRI line bit rate change. After a dynamic CPRI line bit rate change the IP core forces resynchronization internally without referring to this register. |
| 23:17           | Reserved      | UR0  | 7'b0           |  |
| 16              | rx_byte_delay | RO   | 1'b0           | Current byte-alignment delay. This field is relevant for the Rx path delay calculation.  |
| 15:RX_BUF_DEPTH | Reserved      | UR0  | 0              |  |

| Bits                 | Field Name   | Type | Value on Reset | Description  |
|----------------------|--------------|------|----------------|--|
| (RX_BUF_DEPTH - 1):0 | rx_buf_delay | RO   | 0              | Current receive buffer fill level. Unit is 32-bit words. Maximum value is $2^{\text{RX\_BUF\_DEPTH\_1}}$ . |

**Related Information**

[Rx Path Delay](#) on page 3-61

## TX\_EX\_DELAY Register

Table 5-23: CPRI v6.0 IP Core TX\_EX\_DELAY Register at Offset 0x50

| Bits  | Field Name        | Type | Value on Reset | Description  |
|-------|-------------------|------|----------------|--|
| 31:24 | tx_msrn_period    | RW   | 8'b0           | Integration period for Tx buffer extended delay measurement. Program this field with the user-defined value N, where $M/N = \text{ex\_delay\_clk period} / \text{cpri\_clkout period}$ . |
| 23    | tx_ex_delay_valid | RC   | 1'b0           | Indicates that the tx_ex_delay field has been updated.   |
| 22:16 | Reserved          | UR0  | 7'b0           |  |
| 15:0  | tx_ex_delay       | RO   | 16'b0          | Tx buffer extended delay measurement result. Unit is cpri_clkout clock periods.  |

**Related Information**

- [Extended Delay Measurement](#) on page 3-56
- [Extended Delay Measurement Interface](#) on page 3-59

## RX\_EX\_DELAY Register

Table 5-24: CPRI v6.0 IP Core IRX\_EX\_DELAY Register at Offset 0x54

| Bits  | Field Name     | Type | Value on Reset | Description   |
|-------|----------------|------|----------------|---|
| 31:24 | rx_msrn_period | RW   | 8'b0           | Integration period for Rx buffer extended delay measurement. Program this field with the user-defined value $N_R$ , where $M/N_R = \text{ex\_delay\_clk period} / \text{cpri\_clkout period}$ . |



| Bits                 | Field Name        | Type | Value on Reset | Description   |
|----------------------|-------------------|------|----------------|---|
| 23                   | rx_ex_delay_valid | RC   | 1'b0           | Indicates that the rx_ex_delay field has been updated.                          |
| 22:RX_BUF_DEPTH      | Reserved          | UR0  | 0              |   |
| (RX_BUF_DEPTH - 1):0 | rx_ex_delay       | RO   | 0              | Rx buffer extended delay measurement result. Unit is cpri_clkout clock periods. |

**Related Information**

- [Extended Delay Measurement](#) on page 3-56
- [Extended Delay Measurement Interface](#) on page 3-59

## ROUND\_TRIP\_DELAY Register

Table 5-25: CPRI v6.0 IP Core ROUND\_TRIP\_DELAY Register at Offset 0x58

| Bits  | Field Name       | Type | Value on Reset | Description  |
|-------|------------------|------|----------------|--|
| 31:20 | Reserved         | UR0  | 12'b0          |  |
| 19:0  | round_trip_delay | RO   | 20'b0          | Measured round-trip delay from aux_tx_rfp to aux_rx_rfp. Unit is cpri_clkout clock periods. The IP core updates this field with every radio frame. |

**Related Information**

- [Round-Trip Delay](#) on page 3-63

## XCVR\_BITSLIP Register

Table 5-26: CPRI v6.0 IP Core XCVR\_BITSLIP Register at Offset 0x5C

| Bits  | Field Name | Type | Value on Reset | Description |
|-------|------------|------|----------------|-------------|
| 31:21 | Reserved   | UR0  | 11'b0          |             |

| Bits  | Field Name     | Type | Value on Reset | Description  |
|-------|----------------|------|----------------|--|
| 20:16 | rx_bitslip_out | RO   | 5'b0           | Number of bits of delay (bitslip) detected at the receiver word-aligner. Value can change at frame synchronization, when the transceiver is resetting. Any K28.5 symbol position change that occurs when word alignment is activated changes the bitslip value.  |
| 15:6  | Reserved       | UR0  | 10'b0          |  |
| 5     | tx_bitslip_en  | RW   | 1'b0           | Enable manual tx_bitslip_in updates.   |
| 4:0   | tx_bitslip_in  | RW   | 5'b0           | Number of bits of delay (bitslip) the CPRI v6.0 IP core adds at the CPRI Tx link.<br><br>The CPRI line bit rate determines the following maximum values for this field: <ul style="list-style-type: none"> <li>Maximum value for IP core variations with CPRI line bit rate 0.6144 Gbps: 9 bits.</li> <li>Maximum value for IP core variations with CPRI line bit rate greater than 0.6144 Gbps: 19 bits.</li> </ul> |

**Related Information**

[Tx Bitslip Delay](#) on page 3-68

## DELAY\_CAL\_STD\_CTRL1 Register

**Table 5-27: CPRI v6.0 IP Core DELAY\_CAL\_STD\_CTRL1 Register at Offset 0x60**

This register is available only in CPRI IP cores with the single-trip delay calibration feature.

| Bits  | Field Name | Type | Value on Reset | Description   |
|-------|------------|------|----------------|---|
| 31:17 | Reserved   | UR0  | 15'b0          |   |
| 16    | cal_reset  | RW   | 1'b0           | Reset single-trip delay calibration.<br><br>Set this bit to the value of 1 to reset the IP core single-trip delay calibration module and the Intel-provided DPCU module that you have connected to the IP core. Reset this bit to the value of 0 to resume the normal functionality of these two modules.<br><br>Setting this bit to the value of 1 resets all of the single-trip delay calibration logic. This reset does not affect the values in the DELAY_CAL_STD_CTRLn registers. However, the reset does override the value in the cal_int_check field. |

| Bits | Field Name    | Type | Value on Reset | Description   |
|------|---------------|------|----------------|---|
| 15:9 | Reserved      | UR0  | 7'b0           |   |
| 8    | cal_int_check | RW   | 1'b0           | <p>Enable single-trip delay consistency checking. If you set this bit to the value of 1, the IP core checks once per hyperframe that the sum of the <code>cal_step_delay</code> and <code>cal_cycle_delay</code> field values in the <code>DELAY_CAL_STD_CTRL2</code> register match the <code>cal_current_delay</code> field value in the <code>DELAY_CAL_STD_STATUS</code> register. If they do not match, the IP core triggers recalibration.</p> <p>If you set this bit to the value of 0, the IP core performs a consistency check only when you set the <code>cal_en</code> bit. If <code>cal_int_check</code> has the value of 0, the user can schedule consistency checks by resetting and setting the <code>cal_en</code> bit.</p> |
| 7:1  | Reserved      | UR0  | 7'b0           |   |
| 0    | cal_en        | RW   | 1'b0           | <p>Enable single-trip delay calibration.</p> <p>Set this bit to the value of 1 to activate single-trip delay calibration. Reset this bit to the value of 0 to turn off single-trip delay calibration.</p>   |

## DELAY\_CAL\_STD\_CTRL2 Register

**Table 5-28: CPRI v6.0 IP Core DELAY\_CAL\_STD\_CTRL2 Register at Offset 0x64**

This register is available only in CPRI slave IP cores with the single-trip delay calibration feature.

The user provides this information to specify the anticipated or desired duration of the total variable component of the single-trip delay. This value reflects the system requirements.

| Bits  | Field Name      | Type | Value on Reset | Description   |
|-------|-----------------|------|----------------|---|
| 31:25 | Reserved        | UR0  | 7'b0           |   |
| 24:16 | cal_step_delay  | RW   | 9'b0           | Additional fractional <code>cpri_clkout</code> clock cycles of delay in step units. |
| 15:8  | Reserved        | UR0  | 8'b0           |   |
| 7:0   | cal_cycle_delay | RW   | 8'b0           | Delay in full <code>cpri_clkout</code> clock cycles.                                |

## DELAY\_CAL\_STD\_CTRL3 Register

**Table 5-29: CPRI v6.0 IP Core DELAY\_CAL\_STD\_CTRL3 Register at Offset 0x68**

This register is available only in CPRI master IP cores with the single-trip delay calibration feature.

| Bits  | Field Name   | Type | Value on Reset | Description  |
|-------|--------------|------|----------------|--|
| 31:17 | Reserved     | UR0  | 15'b0          |  |
| 16    | cal_send_en  | RW   | 1'b0           | Enable a CPRI master IP core to include TX delay information in outgoing CPRI communication.<br><br>Software must specify the location of this information in the transmitted radio frame by writing the location information in the cal_send_seq and cal_send_x fields.   |
| 15    | Reserved     | UR0  | 1'b0           |  |
| 14:8  | cal_send_seq | RW   | 7'b0           | In a CPRI master IP core, specifies the sequence number in the outgoing basic frame that is the location of the TX delay information the IP core provides to the receiving CPRI slave.<br><br><b>Note:</b> If the CPRI slave that receives CPRI communication from this IP core on the CPRI link is an Intel FPGA CPRI v6.0 IP core, the value in this field must be identical to the value in the cal_rcv_seq field of the DELAY_CAL_STD_CTRL4 register in that CPRI slave. |
| 7:0   | cal_send_x   | RW   | 8'b0           | In a CPRI master IP core, specifies the basic frame number in the incoming hyperframe that is the location of the TX delay information the IP core provides to the receiving CPRI slave.<br><br><b>Note:</b> If the CPRI slave that receives CPRI communication from this IP core on the CPRI link is an Intel FPGA CPRI v6.0 IP core, the value in this field must be identical to the value in the cal_rcv_x field of the DELAY_CAL_STD_CTRL4 register in that CPRI slave. |

## DELAY\_CAL\_STD\_CTRL4 Register

**Table 5-30: CPRI v6.0 IP Core DELAY\_CAL\_STD\_CTRL4 Register at Offset 0x6C**

This register is available only in CPRI slave IP cores with the single-trip delay calibration feature.

| Bits      | Field Name  | Type | Value on Reset | Description   |
|-----------|-------------|------|----------------|---|
| 31:<br>17 | Reserved    | UR0  | 15'b0          |   |
| 16        | cal_rcv_en  | RW   | 1'b0           | <p>Enable a CPRI slave IP core to receive TX delay information in incoming CPRI communication.</p> <p>Software must specify the location of this information in the incoming radio frame by writing the location information in the cal_rcv_seq and cal_rcv_x fields.</p> <p>The cal_tx_delay_usr_en field of the DELAY_CAL_STD_CTRL5 register overrides this register field.</p>   |
| 15        | Reserved    | UR0  | 1'b0           |   |
| 14:<br>8  | cal_rcv_seq | RW   | 7'b0           | <p>In a CPRI slave IP core, specifies the sequence number in the incoming basic frame that is the location of the TX delay information provided by the transmitting CPRI master.</p> <p><b>Note:</b> If the CPRI master that transmits to this IP core on the CPRI link is an Intel FPGA CPRI v6.0 IP core, the value in this field must be identical to the value in the cal_send_seq field of the DELAY_CAL_STD_CTRL3 register in that CPRI master.</p> |
| 7:0       | cal_rcv_x   | RW   | 8'b0           | <p>In a CPRI slave IP core, specifies the basic frame number in the incoming hyperframe that is the location of the TX delay information provided by the transmitting CPRI master.</p> <p><b>Note:</b> If the CPRI master that transmits to this IP core on the CPRI link is an Intel FPGA CPRI v6.0 IP core, the value in this field must be identical to the value in the cal_send_x field of the DELAY_CAL_STD_CTRL3 register in that CPRI master.</p> |

## DELAY\_CAL\_STD\_CTRL5 Register

Table 5-31: CPRI v6.0 IP Core DELAY\_CAL\_STD\_CTRL5 Register at Offset 0x70

This register is available only in CPRI slave IP cores with the single-trip delay calibration feature.

| Bits      | Field Name | Type | Value on Reset | Description |
|-----------|------------|------|----------------|-------------|
| 31:<br>17 | Reserved   | UR0  | 15'b0          |             |

| Bits      | Field Name          | Type | Value on Reset | Description  |
|-----------|---------------------|------|----------------|--|
| 16        | cal_tx_delay_usr_en | RW   | 1'b0           | Enable a CPRI slave IP core to receive TX delay information in the cal_tx_delay_usr field.<br><br>When the value of this field is 1, the IP core cannot receive TX delay information in incoming CPRI communication. |
| 15:<br>12 | Reserved            | UR0  | 4'b0           |  |
| 11:<br>0  | cal_tx_delay_usr    | RW   | 12'b0          | TX delay value provided by software. This field is valid only when the cal_tx_delay_usr_en field has the value of 1.<br><br>Unit is clk_ex_delay clock cycles.   |

## DELAY\_CAL\_STD\_STATUS Register

**Table 5-32: CPRI v6.0 IP Core DELAY\_CAL\_STD\_STATUS Register at Offset 0x74**

This register is available only in CPRI slave IP cores with the single-trip delay calibration feature.

| Bits      | Field Name        | Type | Value on Reset | Description  |
|-----------|-------------------|------|----------------|--|
| 31:<br>16 | Reserved          | UR0  | 16'b0          |  |
| 15:<br>0  | cal_current_delay | RO   | 16'b0          | Variable delay from the synchronization service access point (SAP) in the CPRI link master to the synchronization SAP in this CPRI v6.0 slave IP core. Unit is clk_ex_delay clock cycles.<br><br>The IP core calculates this value. The Intel-provided single-trip delay calibration modules use this value to determine the values they write to the cal_step_delay and cal_cycle_delay fields of the IP core's DELAY_CAL_STD_CTRL2 register. |

## DELAY\_CAL\_RTD Register

**Table 5-33: CPRI v6.0 IP Core DELAY\_CAL\_RTD Register at Offset 0x80**

This register is available only in CPRI master IP cores with the single-trip delay calibration feature.

| Bits      | Field Name | Type | Value on Reset | Description |
|-----------|------------|------|----------------|-------------|
| 31:<br>30 | Reserved   | UR0  | 2'b0           |             |

| Bits      | Field Name     | Type | Value on Reset | Description  |
|-----------|----------------|------|----------------|--|
| 29:<br>28 | cal_rtd_status | RW   | 2'b0           | Round trip delay calibration status. Valid values are: <ul style="list-style-type: none"> <li>00: Calibration is turned off.</li> <li>01: Calibration is running.</li> <li>11: Error: IP core is unable to meet the calibration requirement.</li> <li>10: Calibration has completed or is in the monitoring stage.</li> </ul>  |
| 27        | Reserved       | UR0  | 1'b0           |  |
| 26:<br>24 | cal_rtd_ctrl   | RW   | 3'b0           | Round trip delay calibration control. Valid values are one-hot: <ul style="list-style-type: none"> <li>Bit [26]: Active high reset bit that resets the calibration block. Use this bit to reset the calibration block after an error or to re-enable the calibration block to take it out of bypass mode.</li> <li>Bit [25]: Enable or disable calibration block bypass mode. When the value of this bit is 1, round trip delay calibration is in bypass mode. When the value of this bit is 0, round trip delay calibration is not in bypass mode.</li> <li>Bit [24]: Enable or disable round trip delay calibration. When the value of this bit is 1, round trip delay calibration is turned on. When the value of this bit is 0, round trip delay calibration is turned off.</li> </ul> |
| 23:<br>20 | Reserved       | UR0  | 4'b0           |  |
| 19:<br>0  | cal_rtd_usr    | RW   | 20'b0          | Desired round-trip delay value. Unit is <code>cpri_clkout</code> cycles.   |

## XCVR\_TX\_FIFO\_DELAY Register

**Table 5-34: CPRI v6.0 IP Core XCVR\_TX\_FIFO\_DELAY Register at Offset 0x84**

This register is present only in IP core variations that target an Intel Stratix 10 device.

| Bits  | Field Name              | Type | Value on Reset | Description   |
|-------|-------------------------|------|----------------|---|
| 31    | tx_pcs_fifo_delay_valid | RO   | 1'b0           | Indicates that the <code>tx_pcs_fifo_delay</code> field has been updated. |
| 30:25 | Reserved                | UR0  | 6'b0           |   |

| Bits  | Field Name               | Type | Value on Reset | Description   |
|-------|--------------------------|------|----------------|---|
| 24:16 | tx_pcs_fifo_delay        | RO   | 9'b0           | Delay count value for the transmitter PCS FIFO. Unit is multiples of $128/\text{latency\_sclk}$ clock cycles (no units). In other words, the latency through the FIFO is $\langle \text{latency\_sclk period} \rangle \times \langle \text{this field value: delay count} \rangle / 128$ .  |
| 15    | tx_core_fifo_delay_valid | RO   | 1'b0           | Indicates that the <code>tx_core_fifo_delay</code> field has been updated.  |
| 14:9  | Reserved                 | UR0  | 6'b0           |   |
| 8:0   | tx_core_fifo_delay       | RO   | 9'b0           | Delay count value for the transmitter core FIFO. Unit is multiples of $128/\text{latency\_sclk}$ clock cycles (no units). In other words, the latency through the FIFO is $\langle \text{latency\_sclk period} \rangle \times \langle \text{this field value: delay count} \rangle / 128$ . |

## XCVR\_RX\_FIFO\_DELAY Register

**Table 5-35: CPRI v6.0 IP Core XCVR\_RX\_FIFO\_DELAY Register at Offset 0x88**

This register is present only in IP core variations that target an Intel Stratix 10 device.

| Bits  | Field Name               | Type | Value on Reset | Description   |
|-------|--------------------------|------|----------------|---|
| 31    | rx_pcs_fifo_delay_valid  | RO   | 1'b0           | Indicates that the <code>rx_pcs_fifo_delay</code> field has been updated.   |
| 30:25 | Reserved                 | UR0  | 6'b0           |   |
| 24:16 | rx_pcs_fifo_delay        | RO   | 9'b0           | Delay count value for the receiver PCS FIFO. Unit is multiples of $128/\text{latency\_sclk}$ clock cycles (no units). In other words, the latency through the FIFO is $\langle \text{latency\_sclk period} \rangle \times \langle \text{this field value: delay count} \rangle / 128$ . |
| 15    | rx_core_fifo_delay_valid | RO   | 1'b0           | Indicates that the <code>rx_core_fifo_delay</code> field has been updated.  |
| 14:9  | Reserved                 | UR0  | 6'b0           |   |



| Bits | Field Name         | Type | Value on Reset | Description  |
|------|--------------------|------|----------------|--|
| 8:0  | rx_core_fifo_delay | RO   | 9'b0           | Delay count value for the receiver core FIFO. Unit is multiples of $128/\text{latency\_sclk}$ clock cycles (no units). In other words, the latency through the FIFO is $\langle \text{latency\_sclk period} \rangle \times \langle \text{this field value: delay count} \rangle / 128$ . |

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If an IP core version is not listed, the user guide for the previous IP core version applies.

| IP Core Version                | User Guide  |
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| 16.0                           | <a href="#">CPRI v6.0 MegaCore Function User Guide 16.0</a>                           |
| 15.0                           | <a href="#">CPRI v6.0 MegaCore Function User Guide 15.0</a>                           |
| 14.0 and 14.0 Arria 10 Edition | <a href="#">CPRI v6.0 MegaCore Function User Guide 14.0 and 14.0 Arria 10 Edition</a> |

## CPRI v6.0 IP Core User Guide Revision History

Table A-1: Document Revision History

| Date       | Compatible ACDS Version                          | Changes   |
|------------|--|---|
| 2019.01.02 | 17.0 IR3, 17.0, 17.0 Update 1, and 17.0 Update 2 | Clarified the value of <code>xcvr_recovered_clk</code> for the CPRI line bit rates in <i>Table: CPRI v6.0 IP Core Output Clocks</i> . |

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| Date       | Compatible ACDS Version                          | Changes   |
|------------|--|---|
| 2018.01.04 | 17.0 IR3, 17.0, 17.0 Update 1, and 17.0 Update 2 | <ul style="list-style-type: none"> <li>• Updated for the 17.0 software release, including Intel rebranding. Refer to <a href="#">Installation and Licensing</a> on page 2-2, <a href="#">Generating CPRI v6.0 IP Cores</a> on page 2-3, and <a href="#">CPRI v6.0 IP Core File Structure</a> on page 2-3.</li> <li>• Added Stratix 10 device family support for CPRI line bit rates of 1.2288 Gbps through 10.1376 Gbps. Because Stratix 10 device support is not available in the Intel Quartus Prime Pro Edition releases v17.0, v17.0 Update 1, and v17.0 Update 2, this version of the IP core provides Stratix 10 device support only in the Intel Quartus Prime Pro Edition software v17.0 IR3. Auto-rate negotiation and simplex modes are not yet available for CPRI v6.0 IP core variations that target a Stratix 10 device.</li> <li>• Updated speed grade support table in <a href="#">CPRI v6.0 IP Core Performance: Device and Transceiver Speed Grade Support</a> on page 1-5. <ul style="list-style-type: none"> <li>• Added Stratix 10 support.</li> <li>• Added previously missing speed grade information for Arria V GZ devices at CPRI line rate 9.8304 Gbps.</li> <li>• Removed Arria 10 support for the CPRI line rate of 0.6144 Gbps. In the 17.0.260 release, the IP core no longer supports the CPRI line rate of 0.6144 Gbps for Arria 10 devices.</li> <li>• Corrected entries for Arria V GT and Cyclone V GT devices. The previous entries listed speed grades that do not exist for these devices.</li> </ul> </li> <li>• Updated IP core parameters. Refer to <a href="#">CPRI v6.0 IP Core Parameters</a> on page 2-7. <ul style="list-style-type: none"> <li>• Updated default value of <b>Line bit rate</b> parameter. Intel Arria 10 and Intel Stratix 10 devices do not support the CPRI line bit rate of 0.6144 Gbps. The new default value is the lowest CPRI line bit rate the target device family supports: 1228.8 Mbps for Intel Arria 10 and Intel Stratix 10 device families; 614.4 Mbps (as before) for all other supported device families.</li> <li>• Specified the Intel Stratix 10 device family supports only <b>TX/RX Duplex</b> operation mode in the 17.0.260 release.</li> <li>• Moved <b>Core clock source input</b> parameter before <b>Transmitter local clock division factor</b> parameter.</li> <li>• Specified that IP core variations that target an Intel Arria 10 or Intel Stratix 10 device, with <b>Line bit rate</b> set to the value of 4915.2 Mbps or lower, support only the value of <b>1</b> for the <b>Transmitter local clock division factor</b> parameter. This change is new in the 17.0.260 release.</li> <li>• Specified that IP core variations that target a device family other than the Stratix V device family, support only the value of <b>1</b> for the <b>Number of receiver CDR reference clock(s)</b> parameter.</li> <li>• Added new <b>VCCR_GXB and VCCT_GXB supply voltage for the transceiver</b> parameter. This parameter affects the IP core only if it targets an Intel Stratix 10 device.</li> <li>• Specified the <b>Recovered clock source</b> parameter is not available for Intel Arria 10 and Intel Stratix 10 devices. IP cores that target either of these device families, support only a PCS clock source for the <code>xcvr_recovered_clk</code>.</li> <li>• Specified the <b>Enable single-trip delay calibration</b> parameter is only available for Intel Arria 10 devices.</li> <li>• Specified the <b>Enable line bit rate auto-negotiation</b> parameter is not</li> </ul> </li> </ul> |
|            |  | <ul style="list-style-type: none"> <li>• Added information about extended delay measurement for new Stratix 10 hard FIFOs. Refer to <a href="#">Extended Delay Measurement</a> on page 3-56 and the new section <a href="#">Extended Delay Measurement for Intel Stratix 10 Hard FIFOs</a> on page 3-58. The new feature adds the following new parameters and registers:</li> </ul>  |

| Date       | Compatible ACDS Version | Changes  |
|------------|-------------------------|--|
| 2016.07.22 | 16.0                    | <ul style="list-style-type: none"> <li>• Updated for 16.0 software release. Updated release information and resource utilization numbers for the 16.0 software release.</li> <li>• Updated speed grade support table in <i>CPRI v6.0 IP Core Performance: Device and Transceiver Speed Grade Support</i>.</li> <li>• Added Arria 10 and Stratix V device family support for CPRI line bit rate of 8.11008 Gbps. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258.</li> <li>• Removed Arria 10 device family support for CPRI line bit rate of 0.6144 Gbps. This IP core change occurred in the CPRI v6.0 IP core release 15.1.313.</li> <li>• Added support for single-trip delay calibration. This IP core change is new in the CPRI v6.0 IP core release 16.0. <ul style="list-style-type: none"> <li>• Added new parameters <b>Core clock source input</b> and <b>Enable single-trip delay calibration</b>. Refer to <i>CPRI v6.0 IP Core Parameters</i> and <i>Running the Testbench</i>.</li> <li>• Added new clocking structure, new <code>IOPLL</code> and <code>DPCU</code> blocks, and new top-level signal <code>tx_clkout</code>. Refer to <i>CPRI v6.0 IP Core Clocking Structure</i>, <i>CPRI v6.0 IP Core Management Interfaces</i>, <i>Adding the Off-Chip Clean-Up PLL</i>, and new section <i>Example CPRI v6.0 Clock Connections in Different Clocking Modes</i>.</li> <li>• Added new IP core signals <code>cal_status[1:0]</code> and <code>cal_ctrl[15:0]</code>. Refer to <i>Adding and Connecting the Single-Trip Delay Calibration Blocks</i> and <i>Single-Trip Latency Measurement and Calibration Interface Signals</i>.</li> <li>• Added new registers <code>DELAY_CAL_STD_CTRL1</code>, <code>DELAY_CAL_STD_CTRL2</code>, <code>DELAY_CAL_STD_CTRL3</code>, <code>DELAY_CAL_STD_CTRL4</code>, <code>DELAY_CAL_STD_CTRL5</code>, and <code>DELAY_CAL_STD_STATUS</code>. Refer to <i>CPRI v6.0 IP Core Registers</i>.</li> <li>• Added description of new features in new sections <i>Delay Calibration Features</i> and <i>Single-trip Delay Calibration</i>.</li> </ul> </li> <li>• Added support for round-trip latency calibration. This IP core change is new in the CPRI v6.0 IP core release 16.0. <ul style="list-style-type: none"> <li>• Added new parameters <b>Enable round-trip delay calibration</b> and <b>Round-trip delay calibration FIFO depth</b>. Refer to <i>CPRI v6.0 IP Core Parameters</i> and <i>Running the Testbench</i>.</li> <li>• Added new register <code>DELAY_CAL_RTD</code>. Refer to <i>DELAY_CAL_RTD Register</i>.</li> <li>• Added description of new features in new section <i>Round-Trip Delay Calibration</i>.</li> </ul> </li> </ul> |

| Date | Compatible ACDS Version | Changes   |
|------|-------------------------|---|
|      |                         | <ul style="list-style-type: none"> <li>• Added parameters to control Avalon-MM CPU interface addressing mode and to enable ADME support. Refer to <i>CPRI v6.0 IP Core Parameters</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258. <ul style="list-style-type: none"> <li>• Previously the CPU interface addressing mode was always word (4-byte) addressing mode. For CPU interface addressing mode changes, refer to <i>CPU Interface to CPRI v6.0 IP Core Registers</i> and <i>CPU Interface Signals</i>.</li> <li>• You can turn on ADME support to support debugging through the Altera System Console and to expose transceiver registers. This parameter is available only in CPRI v6.0 IP cores that target an Arria 10 device. For additional information about this parameter, refer to <i>Arria 10 Transceiver Reconfiguration Interface</i>.</li> </ul> </li> <li>• The transceiver reconfiguration interface is no longer available in certain configurations of the CPRI v6.0 IP core. Refer to <i>CPRI v6.0 IP Core Parameters</i>, <i>Arria V</i>, <i>Arria V GZ</i>, <i>Cyclone V</i>, and <i>Stratix V Transceiver Reconfiguration Interface</i> and <i>Arria 10 Transceiver Reconfiguration Interface</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258.</li> <li>• The <code>xcvr_rx_is_lockedtoata</code> signal is now available whether or not you turn on <b>Enable debug interface</b> in the parameter editor. Refer to <i>Transceiver Debug Interface</i> and <i>CPRI v6.0 IP Core Transceiver and Transceiver Management Signals</i>. This IP core change is new in the CPRI v6.0 IP core release 16.0.</li> <li>• Expanded width of <code>round_trip_delay</code> field in <code>ROUND_TRIP_DELAY</code> register from 10 bits to 20 bits. Refer to <i>ROUND_TRIP_DELAY Register</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.313.</li> <li>• Added new top-level signals <code>tx_analogreset_ack</code> and <code>rx_analogreset_ack</code>. These signals are available in Arria 10 variations with <b>Enable line bit rate auto-negotiation</b> turned on. Refer to <i>Auto-Rate Negotiation</i> and <i>CPRI v6.0 IP Core Management Interfaces</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258.</li> <li>• Changed name of <code>cpri_10g_coreclk</code> input clock signal to <code>cpri_coreclk</code>. Refer to <i>CPRI v6.0 IP Core Clocking Structure</i> and <i>CPRI v6.0 IP Core Management Interfaces</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258.</li> <li>• Removed <code>xcvr_reset_tx</code> and <code>xcvr_reset_rx</code> signals. Refer to <i>Adding the Reset Controller</i> and <i>CPRI v6.0 IP Core Transceiver and Transceiver Management Signals</i>.</li> <li>• Specified the <b>Recovered clock source</b> parameter is no longer available for CPRI master IP cores. This IP core change is new in the CPRI v6.0 IP core release 16.0.</li> </ul> |

| Date       | Compatible ACDS Version | Changes   |
|------------|-------------------------|---|
|            |                         | <ul style="list-style-type: none"> <li>Specified the <code>xcvr_recovered_clk</code> output clock is available only in CPRI slave IP cores. Refer to <i>CPRI v6.0 IP Core Clocking Structure</i> and <i>Main Transceiver Clock and Reset Signals</i>. This IP core change occurred in the CPRI v6.0 IP core release 15.1.258.</li> <li>Corrected direction of multiple Transceiver Reset Controller signals in Required Connections to and From Reset Controllers in CPRI v6.0 Design table in <i>Adding the Reset Controller</i>.</li> <li>Fixed assorted typos and minor errors.</li> </ul>   |
| 2015.09.29 | 15.0                    | <ul style="list-style-type: none"> <li>Corrected RX GMII Timing Diagram figure. Refer to <i>Gigabit Media Independent Interface (GMII) to External Ethernet Block</i>.</li> <li>Clarified that the limitation of the testbench to CPRI line bit rates other than 614.4 Mbps only applies for Arria 10 devices. All other device families support a testbench for a DUT with the CPRI line bit rate of 614.4 Mbps. Refer to <i>Running the Testbench</i>.</li> </ul>   |
| 2015.09.25 | 15.0                    | <ul style="list-style-type: none"> <li>Changed document part number from UG-01156 to UG-20008. The document title is not affected.</li> <li>Added support for Arria V GT, Arria V GX, Cyclone V GT, and Cyclone V GX devices.</li> <li>Updated for 15.0 software release. Updated release information and resource utilization numbers for the 15.0 software release.</li> <li>Modified device speed grade recommendations: <ul style="list-style-type: none"> <li>Added supported transceiver speed grade information.</li> <li>Added device and transceiver speed grade support information for the previously unsupported device families.</li> </ul> </li> <li>Added support for new GMII interface to external Ethernet block. Refer to <i>Gigabit Media Independent Interface (GMII) to External Ethernet Block</i>.</li> <li>Expanded <i>Deterministic Latency and Delay Measurement and Calibration</i> section. Removed latency numbers and examples, which are now available on the Altera wiki.</li> </ul> |

| Date | Compatible ACDS Version | Changes  |
|------|-------------------------|--|
|      |                         | <ul style="list-style-type: none"> <li>• Updated IP core parameters. Refer to <i>CPRI v6.0 IP Core Parameters</i>. <ul style="list-style-type: none"> <li>• Added new <b>Operation mode</b> parameter. This parameter determines whether the IP core is in TX simplex, RX simplex, or duplex mode. Note the old <b>Operation mode</b> parameter from previous releases is renamed .</li> <li>• Renamed the old <b>Operation mode</b> parameter to <b>Synchronization mode</b>. This parameter determines the default clocking mode of the IP core (Master or Slave clocking mode). Unfortunately, the <code>operation_mode</code> field of the <code>LI_CONFIG</code> register is not renamed. This field supports dynamic reconfiguration of the IP core clocking mode. Refer to <i>LI_CONFIG Register</i>.</li> <li>• Added new <b>Transmitter local clock division factor</b> parameter. This parameter enables you to include multiple instances of the CPRI v6.0 IP core with different CPRI line bit rates using the same external transceiver TX PLL.</li> <li>• Added new <b>Number of receiver CDR reference clock(s)</b> parameter. This parameter supports Stratix V variations in auto-negotiation to or from the CPRI line bit rate of 10.1376 Gbps.</li> <li>• Added new <b>Recovered clock source</b> parameter. This parameter supports auto-negotiation in Stratix V variations to or from the CPRI line bit rate of 10.1376 Gbps.</li> <li>• Changed name of <b>Bit rate (Mbit/s)</b> parameter to <b>Line bit rate (MBit/s)</b>. Enhanced description to include new supported devices.</li> <li>• Changed name of <b>Supported receiver CDR frequency (MHz)</b> parameter to <b>Receiver CDR reference clock frequency (MHz)</b>.</li> <li>• Changed name of <b>Receiver FIFO depth</b> parameter to <b>Receiver soft buffer depth</b>.</li> <li>• Changed name of <b>Enable auto-rate negotiation</b> parameter to <b>Enable line bit rate auto-negotiation</b>.</li> <li>• Changed name of <b>Enable auto-rate negotiation down to 614.4 Mbps</b> parameter to <b>Enable line bit rate auto-negotiation down to 614.4 Mbps</b>.</li> <li>• Changed name of <b>Supported CPU interface standard</b> parameter to <b>Management (CSR) interface standard</b>.</li> <li>• Changed name of <b>Auxiliary latency cycle(s)</b> parameter to <b>Auxiliary and direct interfaces write latency cycle(s)</b>.</li> <li>• Changed name of <b>Enable all control word access</b> parameter to <b>Enable all control word access via management interface</b>.</li> <li>• Changed name of <b>Enable Z.130.0 access interface</b> parameter to <b>Enable direct Z.130.0 alarm bits access interface</b>.</li> <li>• Changed name of <b>Enable real-time vendor specific interface (R-16A)</b> parameter to <b>Enable direct real-time vendor specific interface</b> .</li> <li>• Changed name of <b>Enable L1 inband protocol negotiator</b> parameter to <b>Enable protocol version and C&amp;M channel setting auto-negotiation</b>.</li> <li>• Changed order of some L1 Feature parameters to reflect their new order in the CPRI v6.0 parameter editor.</li> <li>• Changed name of <b>Enable direct HDLC serial interface</b> parameter to <b>Enable HDLC serial interface</b>.</li> <li>• Changed name of <b>Enable IEEE 802.3 100BASE-X 100Mbps MII On/Off</b> parameter to <b>Ethernet PCS interface</b> multi-value parameter, and added</li> </ul> </li> </ul> |

None and MII, when are still available.

- Added allowed value of 11 for **L2 Ethernet PCS Tx/Rx FIFO Depth** parameter, increasing the maximum L2 Ethernet buffer depth to 2048.
- Changed names of loopback-enable parameters to include "serial" or "parallel."

| Date       | Compatible ACDS Version        | Changes   |
|------------|--------------------------------|---|
|            |                                | <ul style="list-style-type: none"> <li>Appended "_n" to names of active low reset signals.</li> <li>Modified recommended reset connections and added four new IP core reset signals: <code>reset_tx_n</code>, <code>reset_rx_n</code>, <code>xcvr_reset_tx</code>, and <code>xcvr_reset_rx</code>.</li> <li>Fixed assorted typos and minor errors.</li> </ul>   |
| 2015.02.16 | 14.0 and 14.0 Arria 10 Edition | <ul style="list-style-type: none"> <li>Corrected name of <code>ROUND_TRIP_DELAY</code> register at offset 0x058. The register name was previously listed incorrectly as <code>ROUND_DELAY</code>.</li> <li>Corrected names of <code>rx_hfnsync</code> and <code>rx_hfnsync_hold</code> fields of <code>L1_STATUS</code> register at offset 0x04. The fields were previously listed incorrectly as <code>rx_state</code> and <code>rx_state_hold</code>.</li> <li>Fixed assorted typos.</li> </ul> <p><b>Note:</b> This version of the user guide documents the same IP core version that the 2014.08.18 user guide documents.</p> |
| 2014.08.18 | 14.0 and 14.0 Arria 10 Edition | Initial release for Arria 10 device support. Corrected multiple figures associated with the AUX interface synchronization signals and the <b>Auxiliary latency cycle(s)</b> parameter. Added discussion of external clean-up PLL in Getting Started chapter. Added multiple sections to Functional Description chapter, including section on latency. Added resource utilization numbers. Moved detailed signal descriptions into relevant sections in Functional Description chapter; the Signals chapter is now a port listing summary. Corrected assorted errors and typos.  |
| 2014.07.28 | 14.0                           | Preliminary restricted document release.  |



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