JESD204B IP

IP Version: v1.5.0

User Guide

FPGA-IPUG-02259-1.6

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Abbreviations in This Document

A list of abbreviations used in this document.

Abbreviation	Definition
ADC	Analog-to-Digital Converter
AXI	Advanced eXtensible Interface
CGS	Code Group Synchronization
CMOS	Complementary Metal Oxide Semiconductor
CSR	Control and Status Register
DAC	Digital-to-Analog Converter
DUT	Device Under Test
DW	Double Word
EBR	Embedded Block RAM
EOF	End of Frame
EOMF	End of Multiframe
ES	Engineering Sample
FMC	FPGA Mezzanine Card
FPGA	Field Programmable Gate Array
FSM	Finite State Machine
FTDI	Future Technology Devices International
GUI	Graphical User Interface
ILA	Initial Lane Alignment
ILAS	Initial Lane Alignment Sequence
IP	Intellectual Property
IQ	In-Phase (I) Component and Quadrature (Q) Component
LFC	Local Frame Clock
LMFC	Local Multiframe Clock
LMMI	Lattice Memory Mapped Interface
LUT4	4-bit Look-up Table
LVDS	Low-Voltage Differential Signaling
MPCS	Multi-protocol Physical Coding Sublayer
PFU	Programmable Functional Unit
PHY	Physical Layer
RBD	Release Buffer Delay
Rx	Receiver
SERDES	Serializer/Deserializer
SOF	Start of Frame
SOMF	Start of Multiframe
Tx	Transmitter
/A/	Control character K28.3
/F/	Control character K28.7
/K/	Control character K28.5
/Q/	Control character K28.4
/R/	Control character K28.0

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1. Introduction

JESD204B is a high-speed serial interface used between data converters, such as analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), and the FPGA device to replace traditional interfaces, such as CMOS and LVDS. With converter sampling rates and data throughput increasing, the JESD204B interface offers advantages in terms of size, cost, and speed.

1.1. Overview of the IP

The Lattice JESD204B IP supports both the Tx and Rx directions, with corresponding PHY, link, and embedded transport layers, on Lattice FPGA devices.

1.2. Quick Facts

Table 1.1. Summary of the JESD204B IP

IP Requirements	Supported Devices	Lattice CertusPro™-NX, Lattice Avant™-G[1], Avant-X[1], Lattice Certus™-N2 (except LN2-CT-20ES)
	IP Changes[2]	Refer to the JESD204B IP Release Notes (FPGA-RN-02006).
Resource Utilization	Supported User Interface	AXI4-Lite, AXI4-Stream
	Resources	Refer to Appendix A for resource utilization samples.
Design Tool Support	Lattice Implementation	IP Core v1.5.0 – Lattice Radiant™ Software 2026.1.1 Lattice Propel™ Design Environment 2026.1.1
	Synthesis	Synopsys® Synplify Pro® for Lattice
	Simulation	Refer to the Lattice Radiant Software User Guide for the list of supported simulators.
Driver Support	API Reference	Refer to the JESD204B Driver API Reference (FPGA-TN-02412).

Notes:

1. Excluding engineering sample (ES) devices.
2. In some instances, the IP may be updated without changes to the user guide. This user guide may reflect an earlier IP version but remains fully compatible with the later IP version. Refer to the IP Release Notes for the latest updates.

1.3. IP Support Summary

Table 1.2. JESD204B IP Support Readiness

Device Family	Simulation Provided	Radiant Timing Model
CertusPro-NX	Yes	Final
Avant-G, Avant-X	Yes	Preliminary
Certus-N2	Yes	Preliminary

The example design for the JESD204B IP allows for simulation and deployment to development boards for testing. Refer to the Example Design section for more details on how to run the example design on hardware and simulation.

1.4. Features

Key features of the JESD204B IP include:

- JESD204B subclass 0 and 1
- Lane rates up to:
  - 8.192 Gb/s for CertusPro-NX devices
  - 9.8304 Gb/s for Avant-G, Avant-X, and Certus-N2 devices
- Configurable lane counts of:
  - 1, 2, or 4 lanes for CertusPro-NX and Certus-N2 devices

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  - 1, 2, 4, or 8 lanes for Avant-G and Avant-X devices
- Scrambler and descrambler support
- SYSREF modes: One-shot and periodic (always)
- Link layer and PHY layer separation modes
- Configurable embedded transport layer

1.5. Licensing and Ordering Information

An IP specific license string is required to enable full use of the JESD204B IP in a complete, top-level design.

The IP can be fully evaluated through functional simulation and implementation (synthesis, map, place and route) without an IP license string. This IP supports Lattice's IP hardware evaluation capabilities. You can create versions of the IP to operate in hardware for a limited time (approximately four hours) without requiring an IP license string. A license string is required to enable timing simulation and to generate a bitstream file that does not include the hardware evaluation timeout limitation.

For more information about pricing and availability of the JESD204B IP, contact your local Lattice Sales Office.

1.5.1. Ordering Part Number

Table 1.3. Ordering Part Number

Device Family	Part Number	
	Single Seat Annual	Single Seat Perpetual
CertusPro-NX	JESD-204B-CPNX-US	JESD-204B-CPNX-UT
Avant-G	JESD-204B-AVG-US	JESD-204B-AVG-UT
Avant-X	JESD-204B-AVX-US	JESD-204B-AVX-UT
Certus-N2	JESD-204B-CN2-US	JESD-204B-CN2-UT

1.6. Minimum Device Requirements

The minimum device requirements for the JESD204B IP with selected link speeds are as follows:

Table 1.4. Minimum Device Requirements for JESD204B IP

Device Family	Link Speed	Speed Grades
CertusPro-NX	8.192 Gb/s	9_High-Performance_1.0V
	7 Gb/s	8_High-Performance_1.0V
	6 Gb/s	7_High-Performance_1.0V
	6 Gb/s	9_Low-Power_1.0V
	5 Gb/s	8_Low-Power_1.0V
	4 Gb/s	7_Low-Power_1.0V
Avant-G, Avant-X	9.8304 Gb/s	2 and 3
	8.5 Gb/s	1
Certus-N2	9.8304 Gb/s	2 and 3
	8.5 Gb/s	1

1.7. Naming Conventions

1.7.1. Nomenclature

The nomenclature used in this document is based on Verilog HDL.

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1.7.2. Signal Names

Signal names that end with:

- *_n* are active low signals (asserted when value is logic 0)
- *_i* are input signals
- *_o* are output signals

1.7.3. Attribute Names

Attribute names in this document are formatted in title case and italicized (*Attribute Name*).

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2. Functional Description

2.1. IP Architecture Overview

The JESD204B IP supports parameterizable PHY layer, link layer, and embedded transport layer, thus providing the capability for custom configuration based on application needs. Figure 2.1 shows the block diagram of the JESD204B IP.

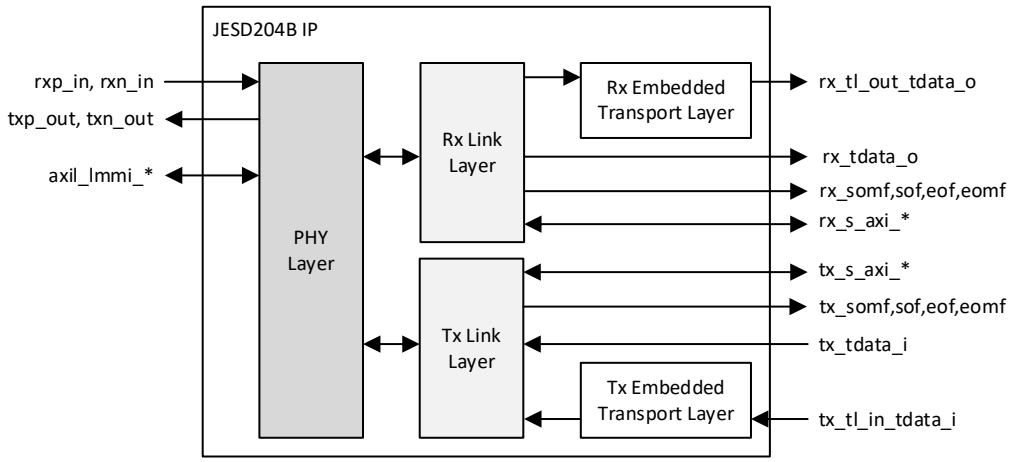


Figure 2.1. JESD204B IP Block Diagram

2.2. Rx Link Layer

Figure 2.2 shows the JESD204B Rx link layer block diagram. An 8b10b decoder is implemented in the PHY layer, which outputs decoded parallel symbols to the Rx multilane alignment module in the Rx link layer.

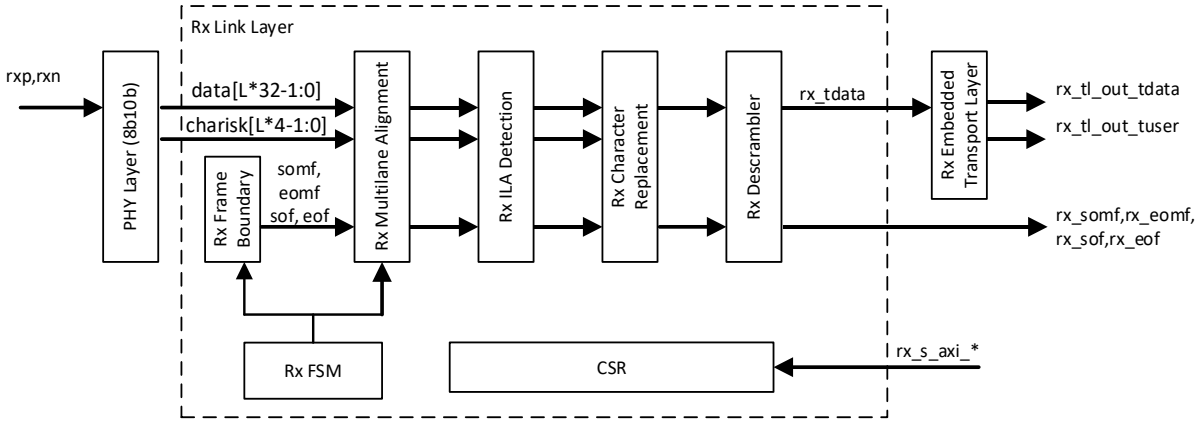


Figure 2.2. JESD204B Rx Link Layer Block Diagram

2.2.1. Frame Boundary and State Machine

The Rx frame boundary module regenerates the local frame clock (LFC) and local multiframe clock (LMFC) in the form of SOF-EOF and SOMF-EOMF close loops, respectively. For subclass 1, the module detects SYSREF assertion as a condition to generate the frame clock. For subclass 0, the module generates the frame clock upon exiting reset.

Figure 2.3 illustrates the LMFC correlation with Rx data frame. SOF to EOF indicates the number of octets per frame (F) while SOMF to EOMF indicates the number of frames per multiframe (K) and number of octets per multiframe (F × K). SOMF is aligned with the LMFC arrow as illustrated in Figure 2.3.

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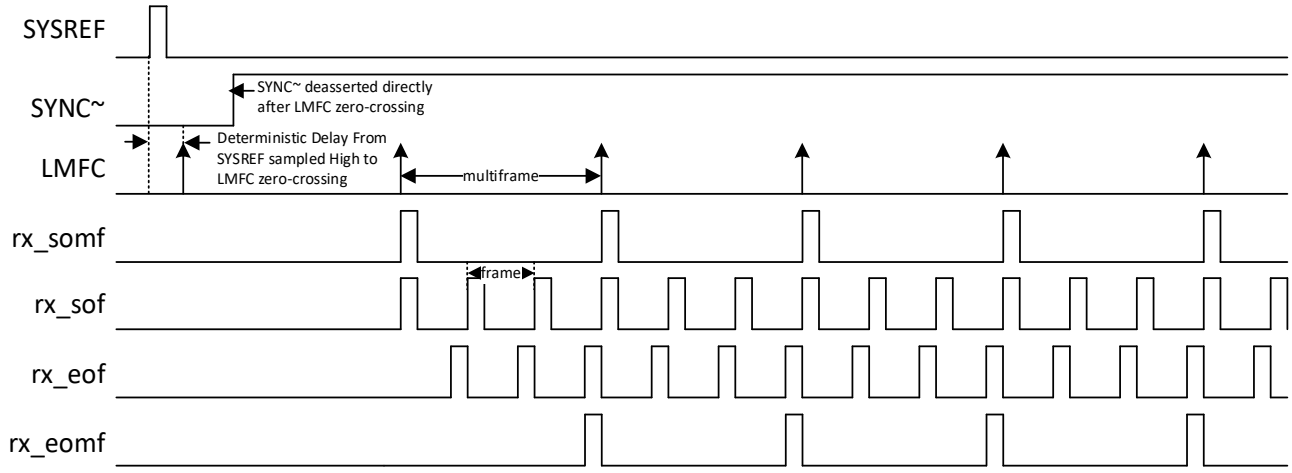


Figure 2.3. Timing Diagram Illustration for LMFC and Rx Frames Interface

The Rx finite state machine (FSM) module indicates the current Rx state through rx_state_o. Table 2.1 shows the four JESD204B Rx states. The rx_sync signal is generated when the link enters the ILA state.

Table 2.1. JESD204B Rx States

Port	Bit Setting	State	Description
rx_state_o	2'd0	IDLE	Default state. Link waits for Rx SYSREF detection before entering code group synchronization (CGS) state.
	2'd1	CGS	SYSREF detected and link is detecting the CGS pattern. Once the CGS pattern for all lanes are detected, link enters ILA state.
	2'd2	ILA	Link is detecting the initial lane alignment sequence (ILAS) symbol and decoding the JESD204B ILA configuration. Link waits for all ILAS multiframes (default is four multiframes) before entering DATA state.
	2'd3	DATA	Rx link is receiving user data. Link enters IDLE state when: • Link reinitialization request is received through Rx register. • Link is reset.

2.2.2. Multilane Alignment

The Rx multilane alignment module has two main functions:

- CGS pattern detection – Upon comma character (/K/) detection on each lane, this module asserts the respective cgs_over signal to indicate that the CGS pattern has been detected.
- Interlane symbol deskew – During serial data transmission, interlane symbol skew may occur causing symbols across lanes to arrive at different times. This module detects the first ILA character (/R/) of the start of ILA multiframe symbol of each lane in order to later release the characters across lanes at the same time through the FIFO with a depth of 2X the number of octets per multiframe.

Note: Octets per multiframe can range from 1 to 8,192. Therefore, FIFO depth can go up to 16K.

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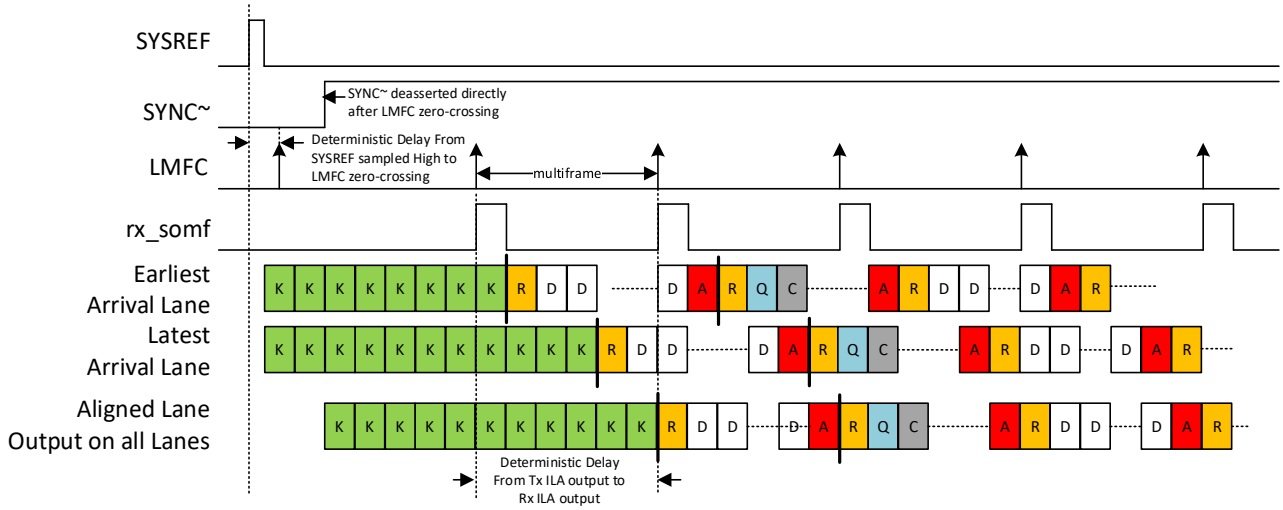


Figure 2.4. Timing Diagram Illustration for Deterministic Latency Equal to Multiples of Multiframe Period

2.2.3. ILA Detection

The Rx ILA detection module detects the ILA sequence and decodes the link configuration parameter. The minimum and default number of ILA multiframes is 4, but the JESD204B specification allows for more than 4 ILA multiframes. The ILA detection module supports an ILA multiframe range of 4 to 256. The Ila_over signal, when asserted, indicates that all ILA multiframes have been detected.

2.2.4. Character Replacement

The JESD204B specification mandates character replacement during the DATA phase depending on whether the scrambler is enabled or disabled (refer to sections 5.3.3.4.2 and 5.3.3.4.3 of the JESD204B specification for more information).

The following are conditions for character replacement by the Rx character replacement module:

- Scrambler is enabled
  - When the last scrambled octet in a frame (rx_eof), but not at the end of multiframe (rx_eomf), equals to control character /F/, Rx character replacement module will decode it as data 0xFC.
  - When the last scrambled octet in a multiframe (rx_eomf) equals control character /A/, Rx character replacement module will decode it as data 0x7C.
- Scrambler is disabled
  - When the last octet in current frame (rx_eof), not coinciding with the end of multiframe (rx_eomf), equals to control character /F/, it will replace current character with the last octet in previous frame (rx_eof).
  - When the last octet in current frame at the end of multiframe (rx_eomf) equals to control character /A/, it will replace current character with the last octet in the previous frame (rx_eof).
  - It is illegal to have two continuous /F/ in back-to-back frames but legal to have /F/ and /A/ in back-to-back frames (because /A/ is EOMF). It is legal to have /F/, /A/, and /F/ in three back-to-back frames.
- Error condition
  - An error condition occurs when the link receives any control character apart from EOF and EOMF. This module passes the receive data through as legal data without fixing the error but increases the error counter.

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2.2.5. Descrambler

The JESD204B scrambler is self-synchronous with a scrambler polynomial as follows:

$$1+x^{14}+x^{15}$$

The period of this polynomial is long enough (32,767 bits) to meet the spectral requirements of sensitive radio applications while allowing the descrambler to self-synchronize in two octets.

The scrambler is disabled during the CGS and ILA phases and enabled during the Data phase after the last ILA EOMF character /A/ is detected.

The descrambler is defined through its serial implementation, processing the received data frame by frame. The left-most bit of the frame is shifted in first as illustrated in Figure 2.5. The actual implementation produces the same result as the serial definition.

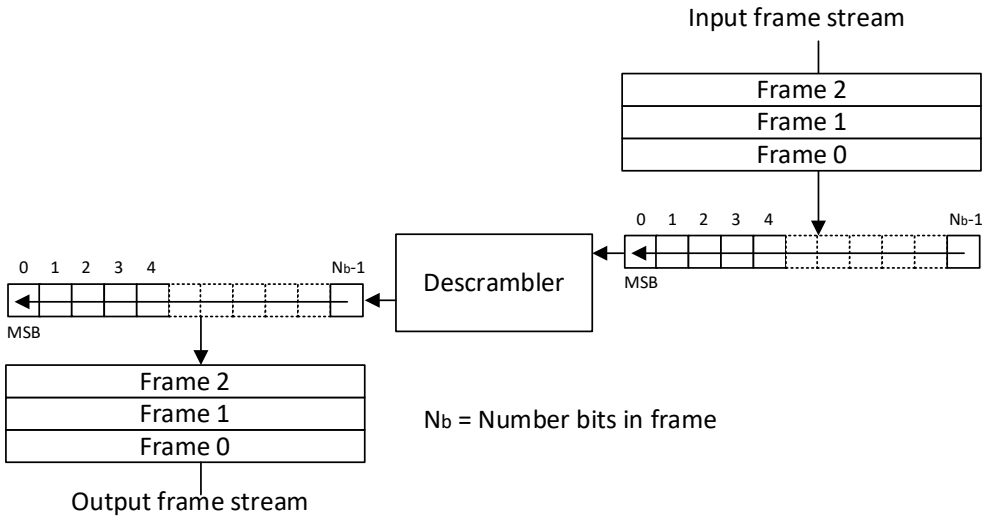


Figure 2.5. Serial Descrambling

2.3. Tx Link Layer

Figure 2.6 shows the JESD204B Tx link layer block diagram. The Tx link layer packetizes tx_tdata from the transport layer with CGS and ILA sequences and transmits to the PHY layer. The Tx scrambler can be enabled or disabled before the ILA sequence.

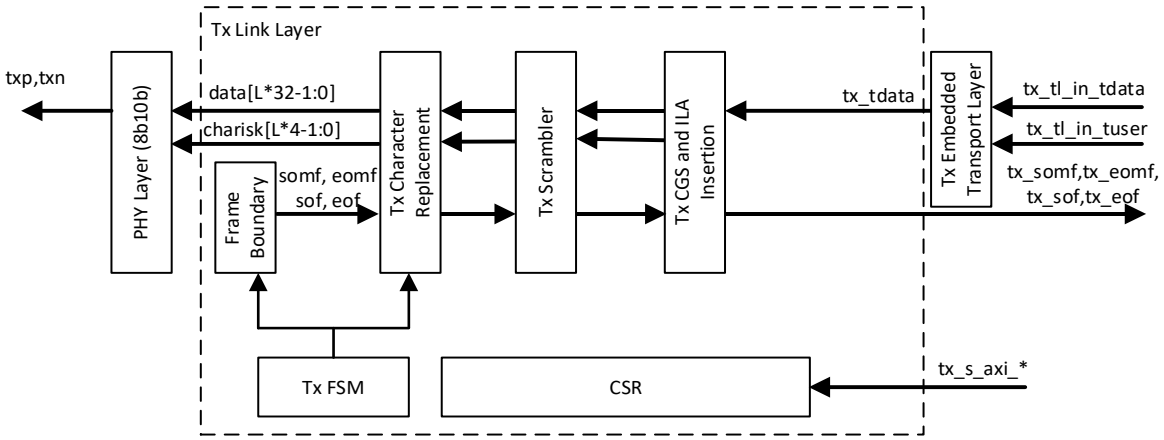


Figure 2.6. JESD204B Tx Link Layer Block Diagram

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2.3.1. Frame Boundary and State Machine

The Tx frame boundary module regenerates the LFC and LMFC in form of SOF-EOF and SOMF-EOMF. For subclass 1, the module detects SYSREF assertion as a condition to generate the frame clock. For subclass 0, the module generates the frame clock upon exiting reset.

The SOF-EOF period depends on the number of octets per frame (F). The SOMF-EOMF period depends on the number of octets per frame (F) and number of frames per multiframe (K).

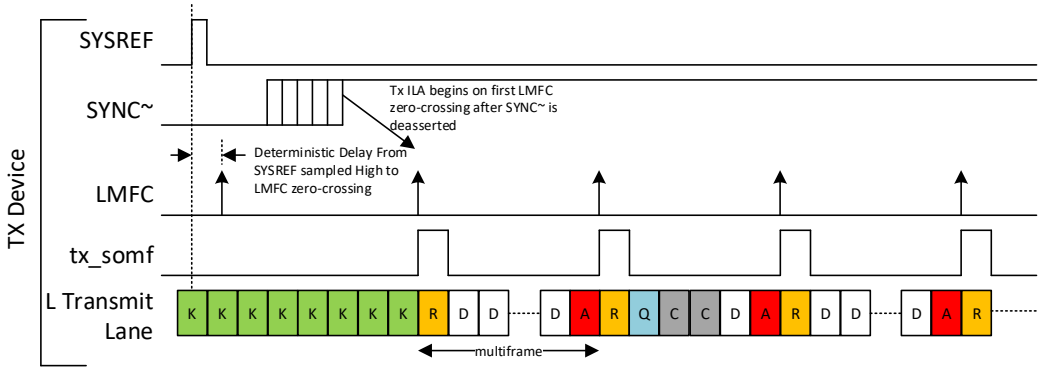


Figure 2.7. Tx LMFC Timing Diagram Correlation with tx_somf Signal

SOMF is aligned with the LMFC arrow as illustrated in Figure 2.7. SOMF and EOMF are aligned with SOF and EOF, respectively.

The Tx FSM module indicates the current Tx state through tx_state_o. Table 2.2 shows the four JESD204B Tx states. This module also detects any resynchronization request from Rx when SYNC~ is asserted (tx_sync_i==0) for at least four LMFC periods (refer to section 8.4 of the JESD204B specification for more information).

Table 2.2. JESD204B Tx States

Port	Bit Setting	State	Description
tx_state_o	2'd0	IDLE	Default state. Link waits for Tx SYSREF detection before entering CGS state.
	2'd1	CGS	SYSREF detected and link is transmitting the CGS pattern. Link enters ILA state when SYNC (tx_sync_i==1) is detected.
	2'd2	ILA	Link is transmitting the ILAS. Once the ILAS is transmitted for all multiframes (default is four multiframes), the link enters DATA state.
	2'd3	DATA	Tx link is transmitting user data received from the transport layer. Link enters IDLE state when: • Link reinitialization request is received – SYNC~ is asserted (tx_sync_i==0) for more than four consecutive LMFC periods. • Link is reset.

2.3.2. CGS and ILA Insertion

The Tx CGS and ILA insertion module inserts CGS and ILA sequence depending on tx_state_o from the Tx FSM. During the CGS phase, the module transmits repeated /K/ symbols until the Rx asserts the SYNC signal. Upon detection of SYNC, the module transmits the ILA sequence that aligns with the LMFC period (tx_somf_i).

The ILA multiframe starts with /R/ and ends with /A/. The ILA sequence consists of at least four multiframes or up to 256 multiframes, configurable through the MULTI_FRAME_IN_ILA parameter. The second multiframe contains the JESD204B link configuration information (refer to sections 8.2 and 8.3 of the JESD204B specification).

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Note: A multiframe is defined as a group of K successive frames, where K is between 1 and 32, such that the number of octets per multiframe is between 17 and 1,024:

$$ceil(17/F) \leq K \leq min\ (32, floor(1024/F))$$

Configuration octet no.	Bits							
	MSB	6	5	4	3	2	1	LSB
0	DID[7:0]							
1	ADJCNT[3:0]				BID[3:0]			
2	X	ADJDIR	PHADJ	LID[4:0]				
3	SCR	X	X	L[4:0]				
4	F[7:0]							
5	X	X	X	K[4:0]				
6	M[7:0]							
7	CS[1:0]		X	N[4:0]				
8	SUBCLASSV[2:0]			Np[4:0]				
9	JESDV[2:0]			S[4:0]				
10	HD	X	X	CF[4:0]				
11	RES1[7:0] - Set to all X							
12	RES2[7:0] - Set to all X							
13	FCHK[7:0]							

Figure 2.8. Mapping of Link Configuration Fields to Octets

2.3.3. Scrambler

The JESD204B scrambler is self-synchronous with a scrambler polynomial as follows:

$$1+x^{14}+x^{15}$$

The scrambler is disabled during the CGS and ILA phases and enabled during the Data phase.
The scrambler is defined through its serial implementation, processing the transmitted data frame by frame. The left-most bit of the frame is shifted in first as illustrated in Figure 2.5. The actual implementation produces the same result as the serial definition.

2.3.4. Character Replacement

The JESD204B specification mandates character replacement during the DATA phase depending on whether the scrambler is enabled or disabled (refer to sections 5.3.3.4.2 and 5.3.3.4.3 of the JESD204B specification for more information).

The following are conditions for character replacement by the Tx character replacement module:

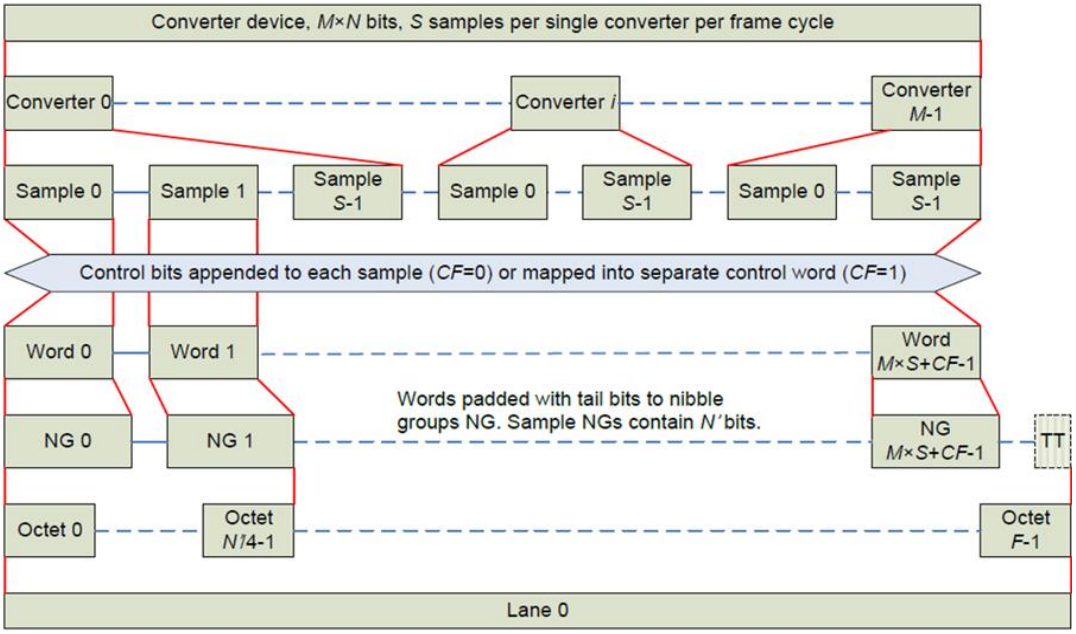
- Scrambler is enabled
  - When the last scrambled octet in a frame (tx_eof), but not at the end of multiframe (tx_eomf), equals 0xFC, Tx character replacement module will encode it as control character /F/.
  - When the last scrambled octet in a multiframe (tx_eomf) equals 0x7C, Tx character replacement module will encode it as control character /A/.
- Scrambler is disabled
  - When the last octet in current frame (tx_eof), not coinciding with the end of multiframe (tx_eomf), equals to the last octet in previous frame (tx_eof), it will be encoded as control character /F/.
  - When the last octet in current frame at the end of multiframe (tx_eomf) equals the last octet in the previous frame (tx_eof), it will be encoded as control character /A/.

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2.4. Embedded Transport Layer

The function of the transport layer is to map the data samples from the converter to a non-scrambled octet. In addition, since the input data width of the core is 32 bits per lane, the transport layer is also responsible for outputting octets that match the expected data width.

Figure 2.9 shows a simple example of how data is mapped from converter samples to octets and output in a lane. Refer to section 5.1 of the JESD204B specification for more examples.



Notes:
1. CF = Number of control words per frame clock period per link
2. F = Number of octets per frame
3. M = Number of converters per device
4. N = Converter resolution
5. N' = Total number of bits per sample
6. S = Number of samples per converter per frame cycle
7. T = Tail bit

Figure 2.9. User Data Format for Independent Lane with Oversampling

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Figure 2.10 shows the embedded transport layer block diagrams for Tx and Rx. The transport layers can be enabled through the respective options in the IP GUI. Refer to the IP Parameter Description and Signal Description sections for the lists of parameters and signals, respectively.

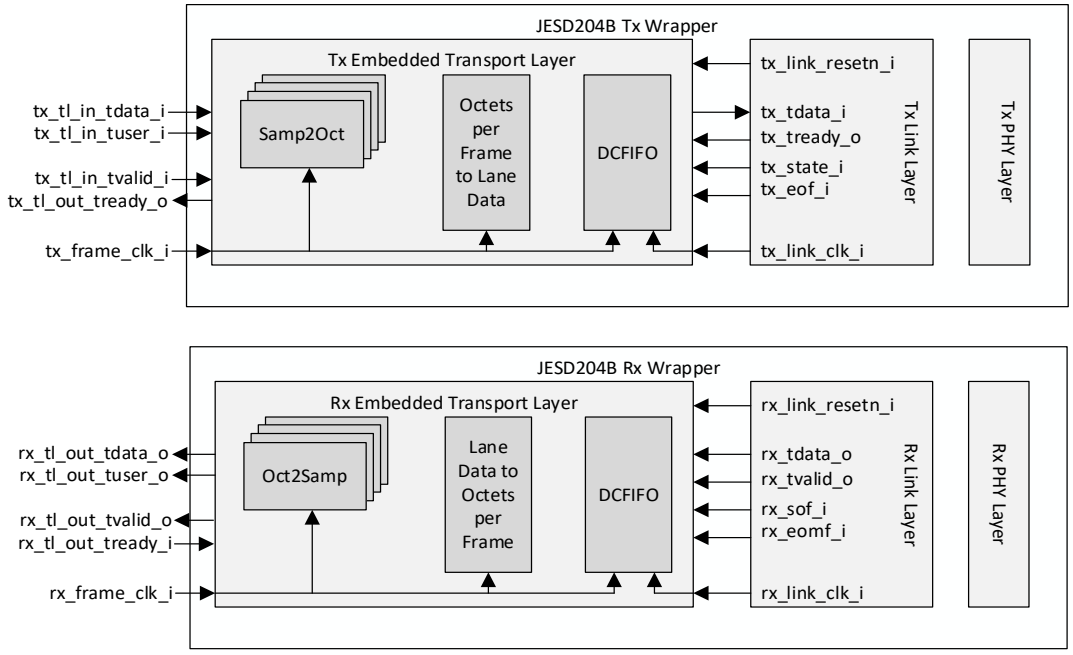


Figure 2.10. Embedded Transport Layer Block Diagrams for Tx and Rx

To calculate the required frame clock frequency, it is important to know that the underlying core is operating at 32 bits per lane in every link clock cycle. These 32 bits are encoded/decoded with 8b10b encoding in the transceiver as required by the JESD204B specification. Hence, the actual link clock frequency can be calculated as follows:

$$Total\ Bits\ Transmitted\ per\ Lane\ per\ Link\ Clock\ Period = 32b \times (10/8) = 40b$$

$$Link\ Clock\ Frequency = Data\ Rate / 40b$$

Since the core is expecting 32 bits of data in every link clock cycle, the frame clock frequency required by the transport layer can be calculated using the JESD204B link parameter octets per frame (F), since F determines how many bits are transmitted per frame clock period (see the data mapping diagram in Figure 2.9), as follows:

$$Frame\ Clock\ Frequency \times (F \times 8) = Link\ Clock\ Frequency \times 32$$

In the scenario where F < 4, the required frame clock frequency may exceed the supported fabric speed depending on the data rate configuration. For example, when data rate = 8.1 Gb/s and F = 1, the required frame clock frequency is 810 MHz. A parameter TL_FRAME_PER_CLK is added to allow multiple frames to be processed at the transport layer in one clock cycle which then lowers the required clock frequency. The updated calculation for the frame clock frequency is as follows:

$$Frame\ Clock\ Frequency \times (F \times 8) \times TL_FRAME_PER_CLK = Link\ Clock\ Frequency \times 32$$

For TL_FRAME_PER_CLK > 1, the samples from all converters for the first frame should be placed at LSB, then only followed by the samples for the second frame and so on. For example, if TL_FRAME_PER_CLK = 4, the tdata bus data bit locations are assigned as follows: {Frame 3 samples, Frame 2 samples, Frame 1 samples, Frame 0 samples}. The transport layer tdata width is byte oriented (8, 16, 24, 32 … bits). Any remaining MSB bits, after packing of all sample data, are padded with 0s.

$$Transport\ Layer\ Data\ Width = ceil((ILA_M+1) \times (ILA_S+1) \times (ILA_N+1) \times TL_FRAME_PER_CLK/8) \times 8$$

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Note: ILA_M, ILA_S, and ILA_N are registers whose values are offset by minus one from the actual values the registers are representing. For example, ILA_M = 0 indicates one converter, ILA_S = 1 indicates 2 samples per converter, and ILA_N = 2 indicates 3 bits per sample.

The following examples are simple illustrations for the timing diagrams of incoming samples from converter devices and the outgoing octet data to the JESD core.

In the first example, the timing diagrams with the link parameter OCTET_PER_FRAME set to 2 and TL_FRAME_PER_CLK set to 2 and 1 are shown in Figure 2.11 and Figure 2.12, respectively.

1. When tx_tl_in_tready is asserted at cycle 0, this indicates that the Tx transport layer is ready to accept data. The first sample from the converter comes in at the same cycle as when tx_tl_in_tvalid is asserted.
2. Later when the transport layer sees tx_tready from the core is asserted, it starts to transmit the lane data to the core at the tx_tdata bus. The data are the remapped samples in octet format where each lane is fixed to a 32-bit wide data bus.

   The LSB of the data bus is usually Octet 0 of the frame and the subsequent byte is followed by Octet 1. Note that these data also need to be aligned with tx_sof output from the core where a bit in tx_sof indicates that a specific byte location in the tx_tdata bus is the start of frame.

   For instance, in the diagram, tx_sof = 0101 indicates that the core is expecting the data at start of frame to be placed at byte locations 0 and 2 in the tx_tdata bus. Hence, at the F0 and F2 positions in the tdata_bus of every lane, the octet is expected to be the data at start of frame from the in*_tdata bus.

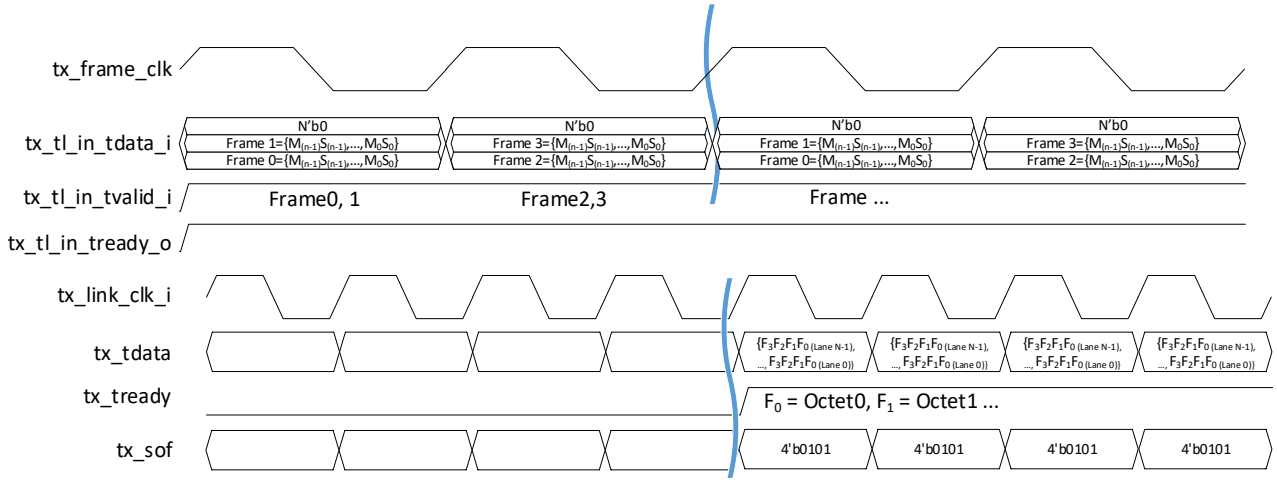


Figure 2.11. Timing Diagram with OCTET_PER_FRAME = 2 and TL_FRAME_PER_CLK = 2

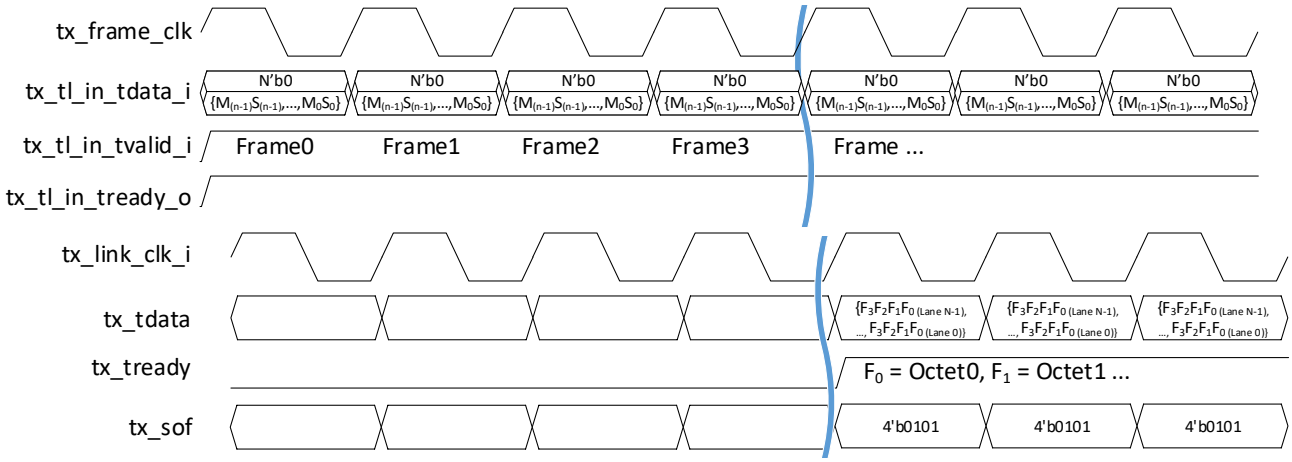


Figure 2.12. Timing Diagram with OCTET_PER_FRAME = 2 and TL_FRAME_PER_CLK = 1

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In the second example, the timing diagrams at the Rx transport layer with OCTET_PER_FRAME set to 3 and TL_FRAME_PER_CLK set to 1 and 2 are shown in Figure 2.13 and Figure 2.14, respectively.

1. As the rx_tvalid signal is asserted, the transport layer starts to accept data from Rx core. Note that at clock cycle 0, rx_sof = 1001 indicates that byte locations 0 and 3 at rx_tdata are the data at start of frame, which means that the data at the F0, F1, and F2 positions of every lane from rx_tdata form the samples of the first frame to the converter while the data at the F3 position are part of the subsequent second frame.
2. At clock cycle 1, the value of rx_sof changes to 0100 indicating that the data at start of frame has changed to byte location 2 at rx_tdata. This means that the data at the F0 and F1 positions in this clock cycle form the samples of the second frame to the converter along with the data at the F3 position from the previous clock cycle. The data at the F2 and F3 positions in this clock cycle are part of the third frame with F2 at lane 0 forming the start of frame.
3. At clock cycle 2, the value of rx_sof changes to 0010 indicating that the data at the F0 position of all lanes in this clock cycle form the last few missing data for the third frame. The data at the F1, F2, and F3 positions of rx_tdata together form the samples of the fourth frame.
4. When the transport layer sees the rx_tl_in_tready signal asserted, it starts outputting the remapped data to the application layer as well as asserting the rx_tl_out_tvalid signal. Note that rx_tl_out_tready and rx_tl_out_tvalid have no dependency on each other and one may assert earlier than the other. Data transfer between manager and subordinate only occurs when both signals are asserted. The Rx_tl_out_tready_i signal is not expected to toggle once it gets asserted as the incoming frame clock and link clock have the same ratio as the input and output data widths, and hence equal in throughput.

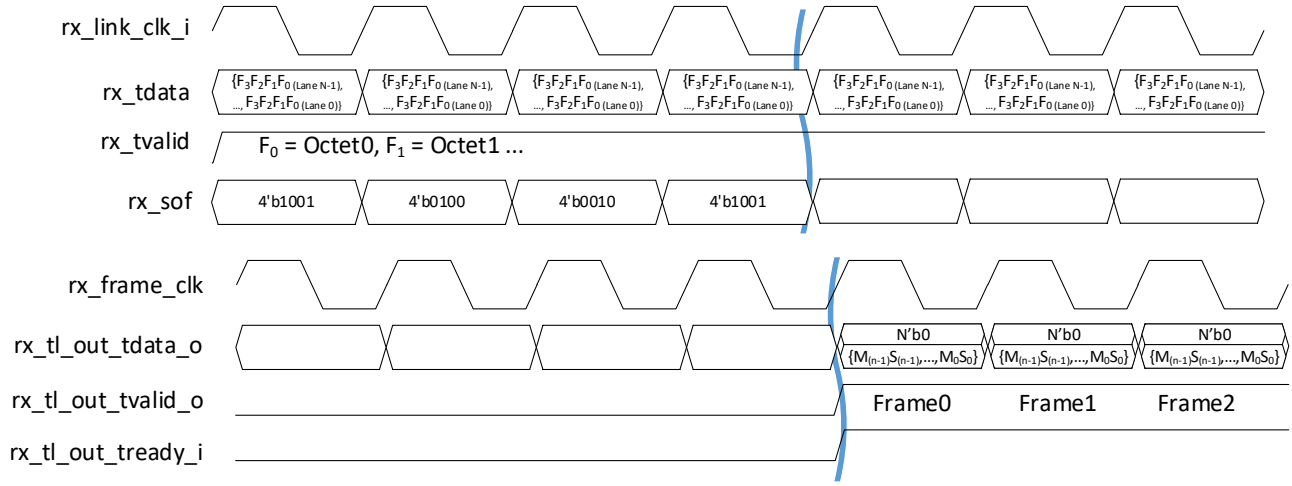


Figure 2.13. Timing Diagram with OCTET_PER_FRAME = 3 and TL_FRAME_PER_CLK = 1

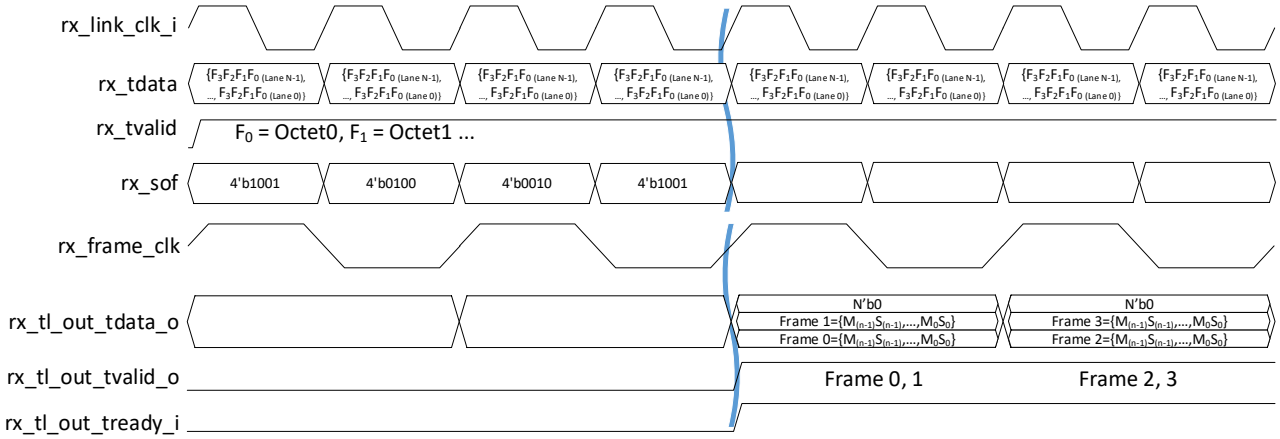


Figure 2.14. Timing Diagram with OCTET_PER_FRAME = 3 and TL_FRAME_PER_CLK = 2

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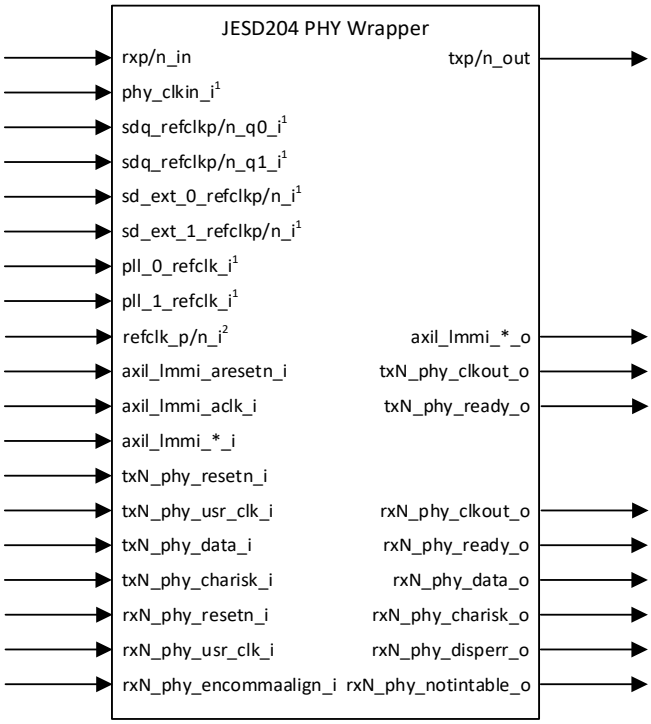
2.5. JESD204B PHY Layer

The JESD204B PHY layer is enabled and preconfigured as part of the JESD204B IP. The IP also handles the reset sequence for the JESD204B PHY layer. You only need to configure the *Data Rate*, *Number of Lanes*, and *Ref Clk Freq* attributes as shown in the IP Parameter Description section.

The JESD204B IP offers the flexibility of enabling or disabling generation of the JESD204B PHY layer through the *JESD204 IP Core Generation Enable* attribute. The JESD204B IP also offers the flexibility of generating only the JESD204B PHY layer (JESD204B PHY layer separation mode). This is accomplished by setting the *JESD204B IP Core Generation Enable* attribute to unchecked and *JESD204 PHY Generation Enable* attribute to checked.

When the JESD204B PHY layer separation mode is enabled, only the JESD204B PHY wrapper and respective interfaces are generated. You need to connect the PHY layer to the link layer manually.

Figure 2.15 shows the JESD204B PHY layer module.



Notes:
1. Applicable for the CertusPro-NX device only.
2. Applicable for the Avant-G/X device only.

Figure 2.15. JESD204B PHY Layer Module

2.5.1. PLL Reference Clock for CertusPro-NX Device

The JESD204B PHY layer supports reference clock selection through the *PMA Reference Clock* attribute. You can select one of six options (sd_ext_0_refclk, sd_ext_1_refclk, sdq0_refclk, sdq1_refclk, pclk0, pclk1) as the PMA reference clock source. The JESD204B PHY layer constrains mux select according to the selection internally so that the output is the selected reference clock. For PCS reference clock information, refer to CertusPro-NX SerDes/PCS User Guide (FPGA-TN-02245).

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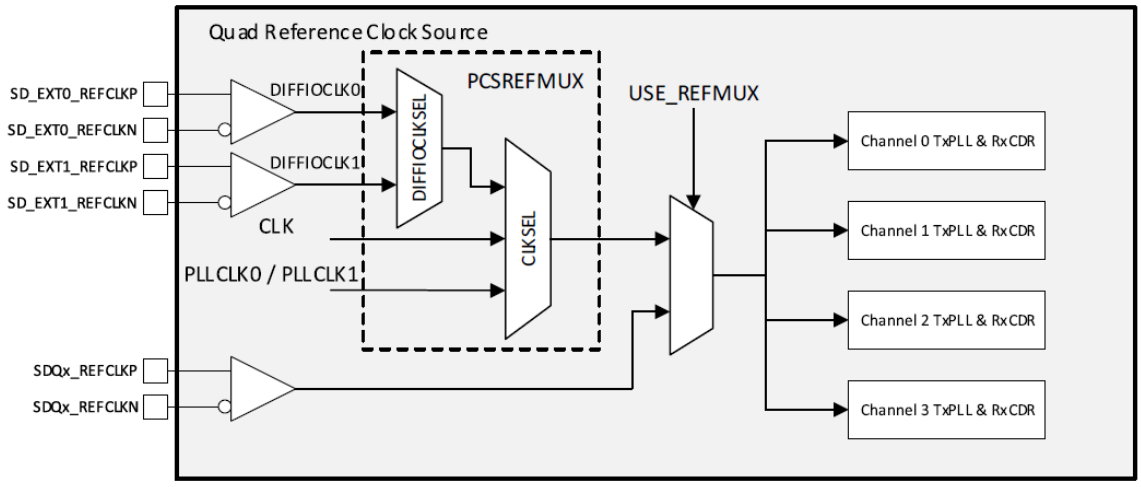


Figure 2.16. CertusPro-NX PCS REFCLK Architecture

2.5.2. AXI4-Lite to LMMI

The JESD204B PHY layer supports access to the PHY layer configuration register through the AXI4-Lite to LMMI interface. AXI4-Lite read and write data are double word (DW) aligned. For register information, refer to the following:

- Lattice Avant SERDES/PCS User Guide (FPGA-TN-02313)
- CertusPro-NX SerDes/PCS User Guide (FPGA-TN-02245)
- Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395)

Figure 2.17 shows the supported AXI4-Lite aligned transfer with respect to 8-bit, 16-bit, or 32-bit transfer. JESD204B AXI4-Lite to LMMI does not support AXI4 unaligned transfer (refer to the AMBA AXI Protocol Specification document). Figure 2.18 and Figure 2.19 show the AXI4-Lite timing diagrams.

Register offset access		31 24	23 16	15 8	7 0
8-bits transfer	Offset 0x0				BYTE0
	Offset 0x1			BYTE1	
	Offset 0x2		BYTE2		
	Offset 0x3	BYTE3			
16-bits transfer	Offset 0x0			BYTE1	BYTE0
	Offset 0x1	Not allowed			
	Offset 0x2	BYTE3	BYTE2		
	Offset 0x3	Not allowed			
32-bits transfer	Offset 0x0	BYTE3	BYTE2	BYTE1	BYTE0
	Offset 0x1	Not allowed			
	Offset 0x2	Not allowed			
	Offset 0x3	Not allowed			

Figure 2.17. AXI4-Lite to LMMI Aligned Transfer on 8-bit, 16-bit, and 32-bit Buses

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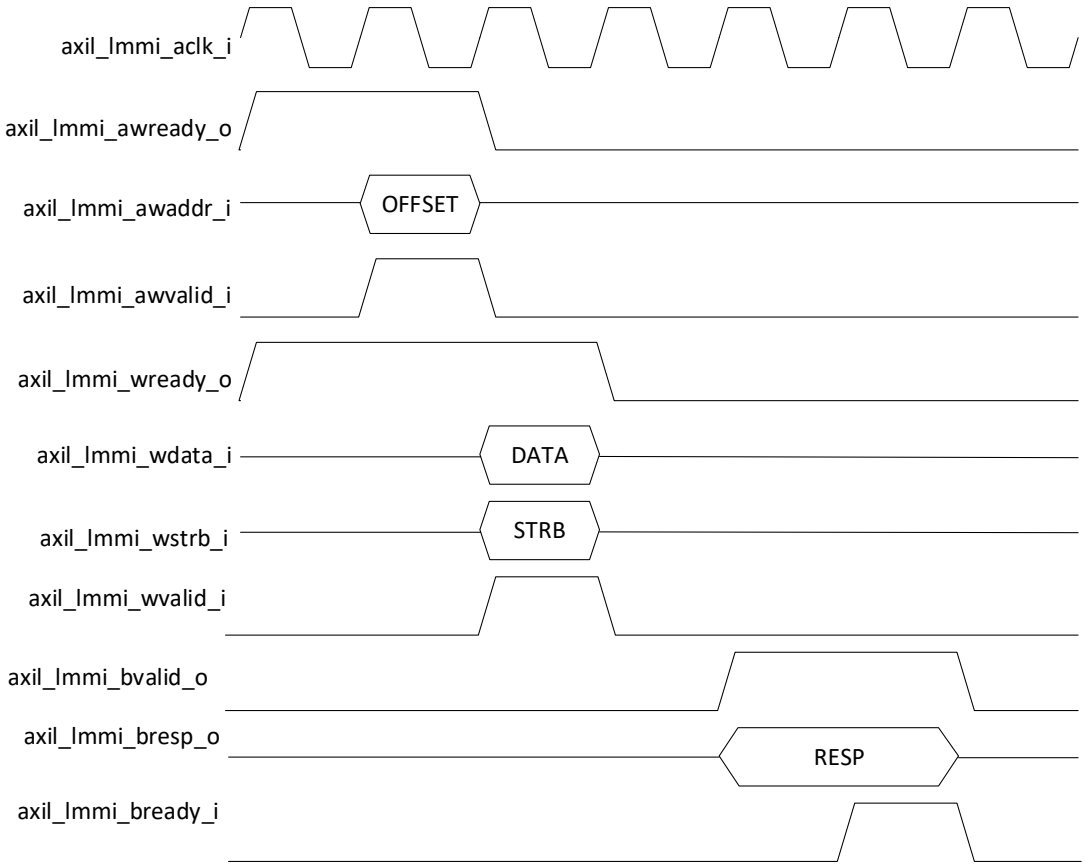


Figure 2.18. AXI4-Lite to LMMI Write Timing Diagram

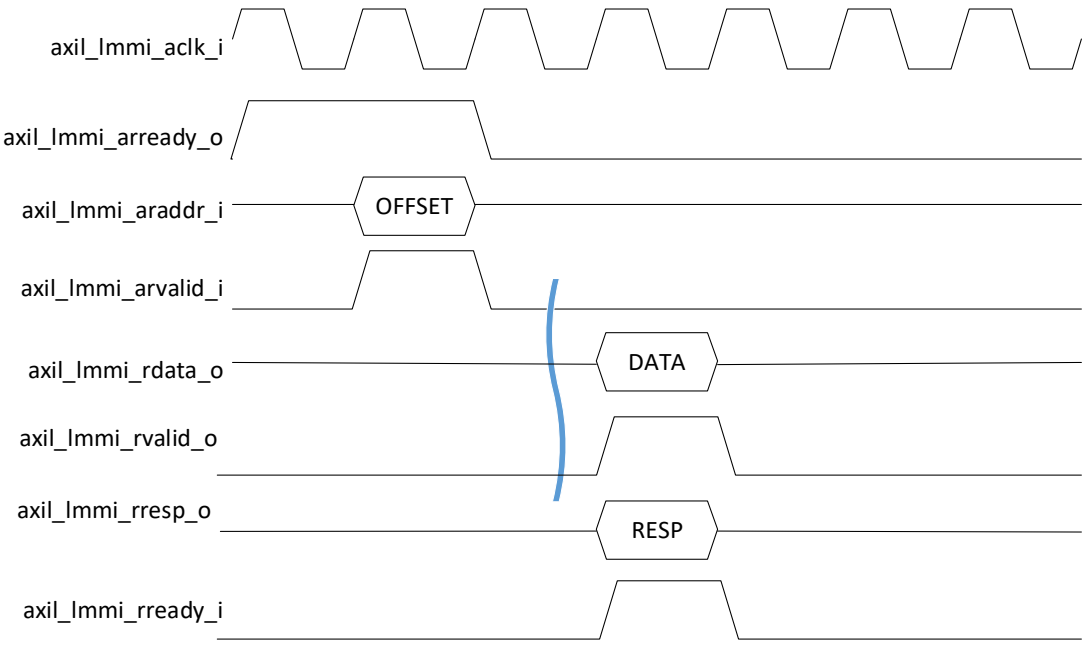


Figure 2.19. AXI4-Lite to LMMI Read Timing Diagram

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2.6. Clocking Overview

This section describes the JESD204B IP clock architecture. Figure 2.20 shows an overview of the JESD204B IP clock domain. All clock domain crossings are handled in the IP.

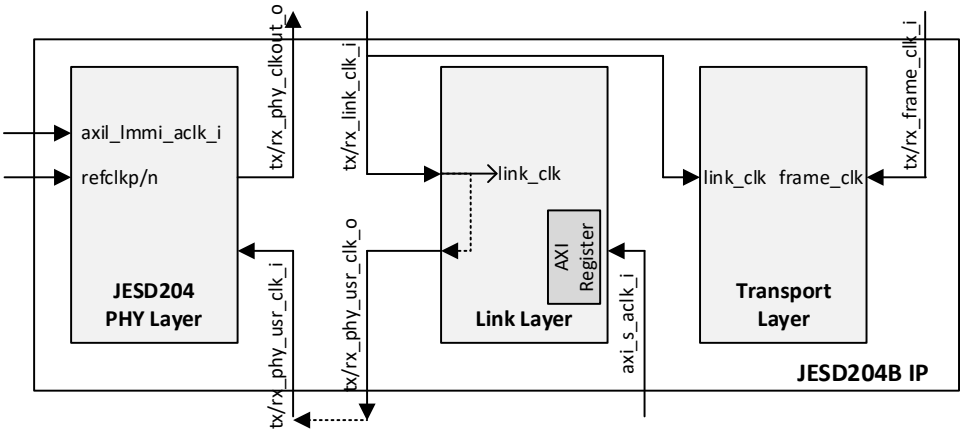


Figure 2.20. JESD204B IP Clock Domain Block Diagram

Refer to the Clock Interface section for descriptions of the JESD204B IP clock signals.

2.7. Reset

This section describes the JESD204B IP reset scheme.

Table 2.3. JESD204B IP Reset Input Overview

Reset	Type	Component to be Reset						
		CSR (AXI4-Lite)		Link and Transport Core		PHY		
		Tx	Rx	Tx	Rx	LMMI Reg	PCS	PMA
Link Wrapper								
tx_s_axi_aresetn_i	Pin	✓	—	✓	—	—	✓	✓
tx_link_resetn_i	Pin	—	—	✓	—	—	✓	✓
Tx Core Reset (CSR offset 0x00 bit[0])	Reg	—	—	✓	—	—	✓	✓
rx_s_axi_aresetn_i	Pin	—	✓	—	✓	—	✓	✓
rx_link_resetn_i	Pin	—	—	—	✓	—	✓	✓
Rx Core Reset (CSR offset 0x00 bit[0])	Reg	—	—	—	✓	—	✓	✓
PHY Wrapper								
axil_lmmi_aresetn_i	Pin	—	—	—	—	✓	✓	✓
txN_phy_resetn_i (see note[1])	Pin	—	—	—	—	—	✓	✓
rxN_phy_resetn_i (see note[1])	Pin	—	—	—	—	—	✓	✓

Note:

1. When the PHY is in Rx_only or Tx_only mode, asserting the respective rxN/txN_phy_resetn_i resets both PMA and PCS. When the PHY is in Rx_and_Tx mode, both txN_phy_resetn_i and rxN_phy_resetn_i must be asserted to reset the PMA and PCS. Otherwise, only the respective Tx PCS and Rx PCS are reset.

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Table 2.4. JESD204B IP Reset Output Overview

Reset	Type	Description
Link and Transport Wrapper		
tx_aresetn_o	Pin	Output reset signal from Tx indicating that link is in reset when de-asserted.
rx_aresetn_o	Pin	Output reset signal from Rx indicating that link is in reset when de-asserted.
PHY Wrapper		
txN_phy_ready_o	Pin	Output ready signal from PHY to indicate that Tx PHY is ready. Used as reset to link layer (excludes AXI register) when phy_ready = 0.
rxN_phy_ready_o	Pin	Output ready signal from PHY to indicate that Rx PHY is ready. Used as reset to link layer (excludes AXI register) when phy_ready = 0.

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3. IP Parameter Description

The configurable attributes of the JESD204B IP are shown in the following tables. You can configure the IP by setting the attributes accordingly in the IP Catalog Module/IP Block wizard of the Lattice Radiant software.

Wherever applicable, default values are in bold.

3.1. General

Table 3.1. General Attributes

Attribute	Selectable Values	Description
JESD204 IP Core Generation Enable	**Checked**, Unchecked	Enables JESD204B link layer IP generation.
Mode	**Rx_and_Tx**, Rx_only, Tx_only	Selects the IP mode.
Data Rate (Gbps)	CertusPro-NX: 0.7425–8.192[1] Avant-G/X, Certus-N2: 1.2288–9.8304[2]	For CertusPro-NX devices, enter the JESD204B data rate in the range from 0.7425 to 8.192 Gb/s. For Avant-G, Avant-X, and Certus-N2 devices, enter the JESD204B data rate in the range from 1.2288 to 9.8304 Gb/s. **Note**: Valid values or ranges are as follows: • 1.2288 Gbps • 1.25–1.289 Gbps • 1.375–2.57812 Gbps • 2.75–5.15625 Gbps • 5.5–6.64062 Gbps • 7.34–9.8304 Gbps
Number of Lanes (L)	**1**, 2, 4, 8	Number of lanes. Only Avant devices support 8 lanes.
Converters per Device (M)	0-255	Sets the number of converters per device. The lowest selectable value corresponds with the lowest allowable setting.
Samples per Converter per Frame (S)	0-31	Sets the number of samples per converter per frame. The lowest selectable value corresponds with the lowest allowable setting.
Converter Resolution (N)	0-31	Sets the number of bits per converter sample. The lowest selectable value corresponds with the lowest allowable setting.
Number of Bits per Sample (Nt)	0-31	Sets the number of bits per sample in user data format. The lowest selectable value corresponds with the lowest allowable setting.
Control Bits (CS)	0-3	Sets the number of control bits per device.
Control Words (CF)	0-31	Sets the number of control words per frame clock per link.
High Density Format (HD)	0, 1	Enables or disables high density format. 0 – Disable high density user data format 1 – Enable high density user data format
Octets per Frame (F)	0-255	Sets the number of octets per frame. The lowest selectable value corresponds with the lowest allowable setting.
Frames per Multiframe (K)	0-31	Sets the number of frames per multiframe. The lowest selectable value corresponds with the lowest allowable setting. **Note:** (Octets per Frame + 1) × (Frames per Multiframe + 1) must be a multiple of 4.
Multi Frames in ILA	3-255	Sets the number of multiframes required in ILAS phase.
Subclass (SUBCLASSV)	0, 1	Selects the JESD204B subclass mode. 0 – Subclass 0 1 – Subclass 1
SYSREF Always	SYSREF_ONCE, SYSREF_ALWAYS	Selects the incoming SYSREF operating mode. SYSREF_ONCE – One shot SYSREF_ALWAYS – Periodic

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Attribute	Selectable Values	Description
Scrambling (SCR)	ENABLED, DISABLED	Enables or disables the scrambler/descrambler.
ILA_DID	0-255	Device (= link) identification number.
ILA_ADJCNT	0-15	Number of adjustment resolution steps to adjust DAC LMFC.
ILA_BID	0-15	Bank ID – Extension to DID
ILA_ADJDIR	0, 1	Direction to adjust DAC LMFC 0 – Advance 1 – Delay
ILA_PHADJ	0, 1	Phase adjustment request to DAC
ILA_JESDV	0, **1**	JESD204 version 000 – JESD204A 001 – JESD204B
ILA_LID	0-31	Lane identification number (within link) for Lane 0. The LID of a subsequent lane is an increment of the LID of the previous lane. For example, for *Number of Lanes*=4 and *ILA_LID*=5, Lane0 LID=5, Lane1 LID=6, Lane2 LID=7, and Lane3 LID=8. The valid range is dependent on the number of lanes: If *Number of Lanes*=1, the valid range is 0-31. If *Number of Lanes*=2, the valid range is 0-30. If *Number of Lanes*=4, the valid range is 0-28.

Notes:

1. The CertusPro-NX device supports data rates up to 8.192 Gb/s.
2. The Avant-G, Avant-X, and Certus-N2 devices support multiple continuous data rate ranges up to 9.8304 Gb/s.

3.2. PHY

Table 3.2. PHY Attributes

Attribute	Selectable Values	Description
JESD204 PHY Generation Enable	**Checked**, Unchecked	Enables JESD204B PHY layer generation.
Lane ID	CertusPro-NX: **0**-7 Avant-G/X: **0**-27 Certus-N2: **0**-7	Selects lane placement location.
PMA Reference Clock	**sd_ext_0_refclk,** sd_ext_1_refclk, sdq0_refclk, sdq1_refclk, pclk0, pclk1	Selects PHY PLL REFCLK source for CertusPro-NX devices.

Ref Clk Freq (MHz)	**156.25**	PHY PLL REFCLK
		Supported reference clock frequency:
		• CertusPro-NX: 74.25–162 MHz
		  • For data rates in the range from 2.97 to 6.48 Gb/s, the recommended frequency is *Data Rate / 40*.
		  • For data rates > 6.48 Gb/s, divide *Data Rate / 40* by a factor of 2 to get a frequency within the recommended range. For example, with the data rate of 8.192 Gb/s, use 102.4 MHz.
		  • For data rates < 2.97 Gb/s, multiply *Data Rate / 40* by one or more factors of 2 to get a frequency within the recommended range. For example, with the data rate of 1.5 Gb/s, use 150 MHz.
		• Avant-G/X and Certus-N2: 20–312.5 MHz
		  • Select the reference clock frequency from the list of available clock frequencies.

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Attribute	Selectable Values	Description
PLL M Setting	1, 2, 4, 8	PHY PLL M setting. Only applicable for CertusPro-NX device.
LMMI AXI-L Address Width	1–32	Width of the AXI4-Lite to LMMI interface address bus.
Data Polarity Inversion Enable	Checked, **Unchecked**	Enables PHY data polarity inversion for CertusPro-NX devices. Refer to CertusPro-NX SerDes/PCS User Guide (FPGA-TN-02245) for more information.

3.3. Transport Layer Setup

Note: The transport layer setup attributes are optional, contingent upon the *JESD204 IP Core Generation Enable* attribute being set to checked.

Table 3.3. Transport Layer Setup Attributes

Attribute	Selectable Values	Description
Transport Layer Enable	Checked, **Unchecked**	Enables the embedded transport layer.[1]
Frame Per Clock	1, 2, 4	Sets the number of frames per frame clock in the transport layer.

Note:

1. Only supported when F = 0, 1, 2, 3, 5, or 7.

3.4. Test Mode Setup

Note: The test mode setup attributes are optional, contingent upon the *JESD204 IP Core Generation Enable* attribute being set to checked.

Table 3.4. Test Mode Setup Attributes

Attribute	Selectable Values	Description
Test Mode Enable	Checked, **Unchecked**	Enables the JESD204B test mode.
Supports Continuous /K28.5/ Character	Always	Specifies support for the JESD204B Tx repetitive K28.5 character generator.
Supports Continuous /D21.5/ Character	Always	Specifies support for the JESD204B Tx repetitive D21.5 character generator.
Supports RPAT Pattern Generator	Checked, **Unchecked**	Enables or disables support for the JESD204B Tx RPAT pattern generator.
Supports JSPAT Pattern Generator	Checked, **Unchecked**	Enables or disables support for the JESD204B Tx JSPAT pattern generator.

3.5. IP Parameter Settings for Example Use Cases

In addition to the JESD204B PHY and Link Layer mode, the JESD204B IP also supports the JESD204B PHY layer and JESD204B link layer separation modes. Link and PHY separation allows for customization of the JESD204B application through:

- Channel lane reversal connection – connections between the PHY layer and link layer can be between different lane numbers, for example, Lane 0 in PHY layer to Lane 3 in link layer.
- Different Tx and Rx configurations – transmitter and receiver can be configured with a different number of lanes such as 1T2R (transmitter configured to one lane, receiver configured to two lanes). This cannot be achieved in the JESD204B PHY and Link Layer mode.

3.5.1. JESD204B PHY and Link Layer Mode

This mode embeds the JESD204B PHY and link layers within a single top module instance. The PHY to link data is handled internally except PHY to link clock.

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The Tx PHY clock out and Rx PHY clock out need to be manually connected to the Tx link clock in and Rx link clock in, respectively. It is recommended that the main channel of PHY clock out be connected to the link clock.

Figure 3.1 shows an example clock connection from PHY to link with channel 0 as the main channel.

Table 3.5. Attributes to Enable JESD204B PHY and Link Layer Mode

Attribute	Configuration Value	Description
JESD204 IP Core Generation Enable	**Checked**	Check to enable JESD204B link layer generation.
JESD204 PHY Generation Enable	**Checked**	Check to enable JESD204B PHY layer generation.
Transport Layer Enable	**Checked** (if needed)	Check to enable the embedded transport layer if needed.

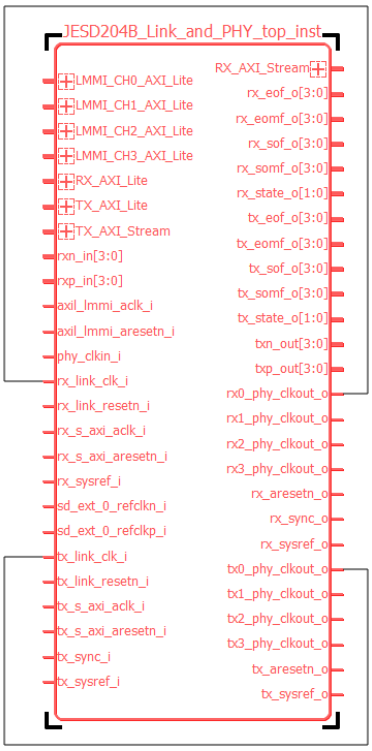


Figure 3.1. JESD204B PHY to Link Connection Example with Main Channel (Channel 0)

3.5.2. JESD204B Link Layer Only Mode

In this mode, only the JESD204B link layer and optional embedded transport layer are generated within the top module instance with the JESD204B PHY layer excluded. All necessary PHY-to-link interfaces are exported to the top level and connections need to be completed manually.

These PHY-to-link interfaces are grouped as JESD204_TX/RX_CORE_CHn interface buses to ease connection using Propel. The PHY clock to link clock connections are as described in the JESD204B PHY and Link Layer Mode section.

Figure 3.2 shows an example PHY-to-link connection through Propel for the JESD204B Link Only mode.

Table 3.6. Attributes to Enable JESD204B Link Only Mode

Attribute	Config Values	Description
JESD204 IP Core Generation Enable	**Checked**	Check to enable JESD204B link layer generation.
JESD204 PHY Generation Enable	**Unchecked**	Uncheck to disable JESD204B PHY layer generation.
Transport Layer Enable	**Checked (if needed)**	Check to enable the embedded transport layer if needed.

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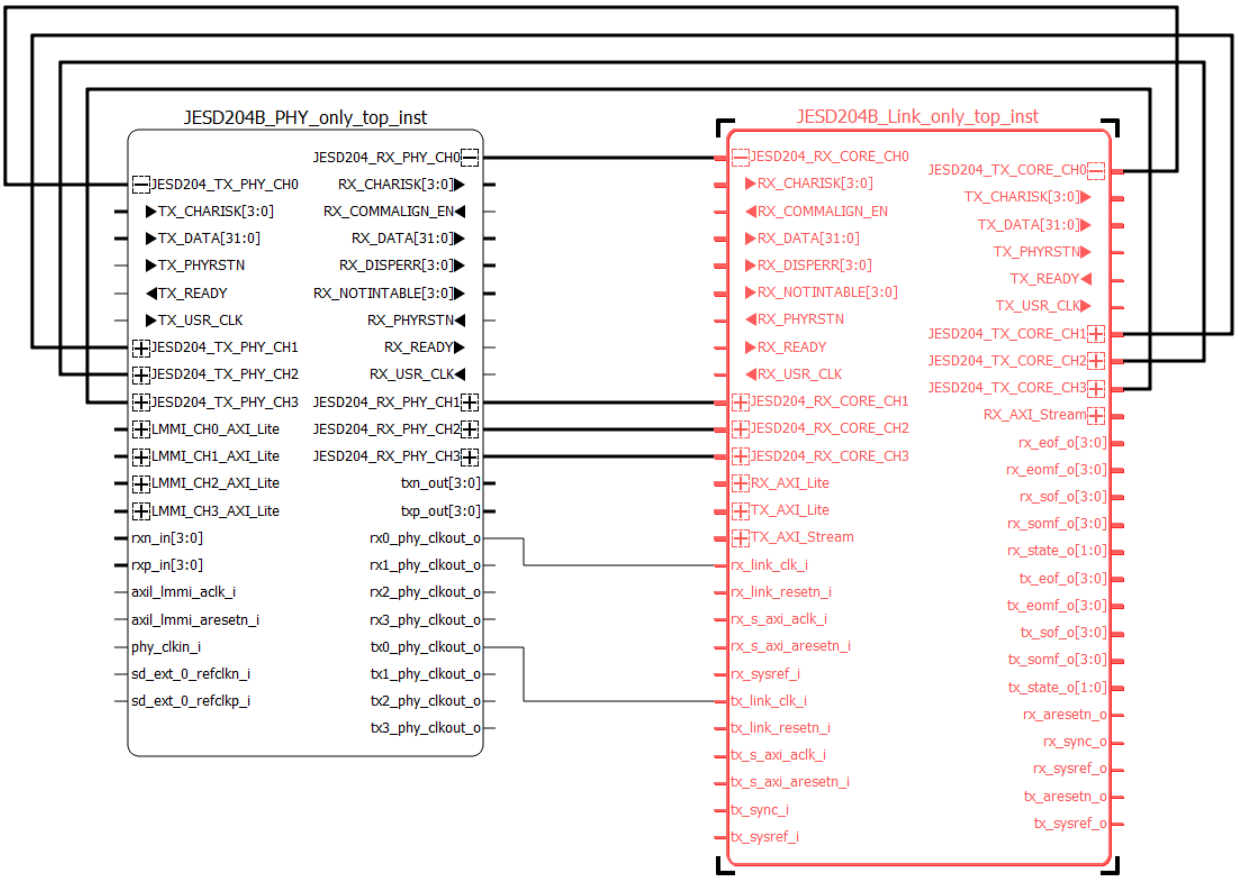


Figure 3.2. JESD204B Link Only Mode Connection Example

3.5.3. JESD204B PHY Layer Only Mode

In this mode, only the JESD204B PHY layer is generated within the top module instance. All necessary PHY-to-link interfaces are exported to the top level and connections need to be completed manually.

These PHY-to-link interfaces are grouped as JESD204_TX/RX_PHY_CHn interface buses to ease connection using Propel. The PHY clock to link clock connections are as described in the JESD204B PHY and Link Layer Mode section.

Figure 3.3 shows an example PHY-to-link connection through Propel for the JESD204B PHY Only mode.

Table 3.7. Attributes to Enable JESD204B PHY Only Mode

Attribute	Config Values	Description
JESD204 IP Core Generation Enable	**Unchecked**	Uncheck to disable JESD204B link layer generation.
JESD204 PHY Generation Enable	**Checked**	Check to enable JESD204B PHY layer generation.

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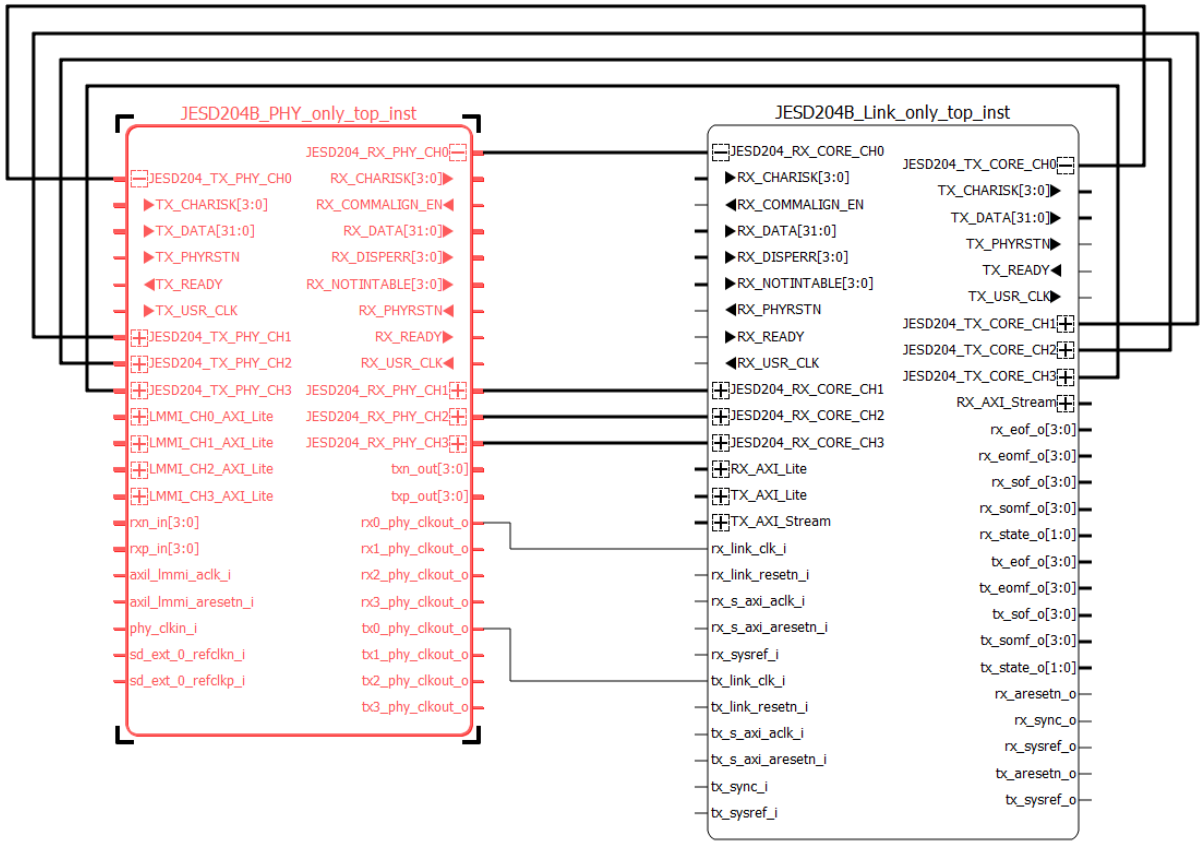


Figure 3.3. JESD204B PHY Only Mode Connection Example

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4. Signal Description

This section describes the JESD204B IP ports.

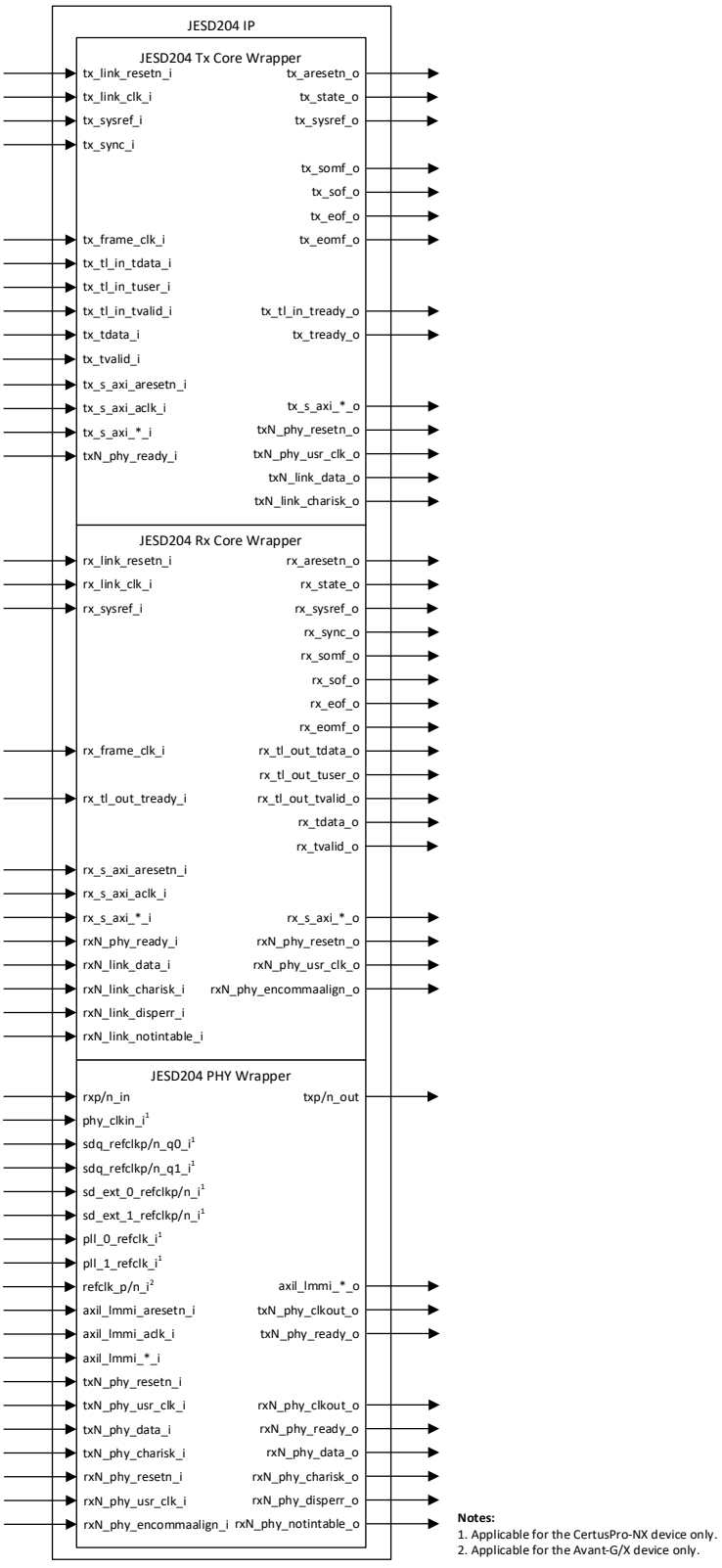


Figure 4.1. JESD204B IP Port Interface Overview

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4.1. Signal Interface

Table 4.1. Signal Ports

Port[1]	Type	Width	Description
JESD Tx Link and Transport Layer Interface [Clock domain = tx_link_clk_i]			
tx_link_resetn_i	Input	1	Tx link layer and transport layer reset (active low). Resets PHY wrapper PCS and PMA.
tx_link_clk_i	Input	1	JESD204B link clock to Tx link. Recommended to connect to device clock from an external clock chip which is generating SYSREF.
tx_sysref_i	Input	1	SYSREF input for JESD204B subclass 1 implementation. Tied off for subclass 0. Recommended to generate this signal from an external clock chip which has a matched trace length with the device clock.
tx_sysref_o	Output	1	Retransmit of tx_sysref_i.
tx_sync_i	Input	1	SYNC input from JESD204B Rx or converter device. 0 – Synchronization request or error reporting from Rx. 1 – Rx in SYNC and ready for ILAS and data phase.
tx_state_o	Output	2	Indicates Tx link progress. 2'b00 – IDLE stage 2'b01 – CGS in progress 2'b10 – ILAS in progress 2'b11 – User data phase
tx_sof_o	Output	4	Indicates start of frame.
tx_somf_o	Output	4	Indicates start of multiframe.
tx_eof_o	Output	4	Indicates end of frame.
tx_eomf_o	Output	4	Indicates end of multiframe.
tx_aresetn_o	Output	1	Active low output reset. Assert (reset) when JESD core is in reset or PHY is not ready.
tx_tdata_i	Input	NUMBER_OF_LANES × 32	Tx link data input from external transport layer where four octets are packed into 32-bit data per lane. Channel 0 always starts from LSB. Available when *Transport Layer Enable* attribute is set to unchecked.
tx_tvalid_i	In	1	Indicates that tdata is valid. This signal is unused internally but exported for AXI-Streaming protocol compliance. You may tie this input signal to 1'b1. Available when *Transport Layer Enable* attribute is set to unchecked.
tx_tready_o	Output	1	Ready signal indicating that the Tx link is ready to accept data. Available when *Transport Layer Enable* attribute is set to unchecked.

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Port[1]	Type	Width	Description
JESD Rx Embedded Transport Layer Interface (Available when *Transport Layer Enable* attribute is set to checked**)** **[Clock domain = tx_frame_clk_i]**			
tx_frame_clk_i	Input	1	Frame clock. This clock must be derived from the device clock source in a JESD204B system. The required clock frequency is (Data Rate) / ((F × 10) × (TL_FRAME_PER_CLK)). Refer to the Clock Interface section for more information.
tx_tl_in_tdata_i	Input	ceil((ILA_M+1) × (ILA_S+1) × (ILA_N+1) × TL_FRAME_PER_CLK/ 8) × 8	Input data port from application layer to transport layer. Refer to the Embedded Transport Layer section for information.
tx_tl_in_tuser_i	Input	(ILA_M+1) × (ILA_S+1) × (ILA_CS+1) × TL_FRAME_PER_CLK	Input data port for control bits to transport layer from application layer. Refer to the Embedded Transport Layer section for information.
tx_tl_in_tvalid_i	Input	1	Valid signal to indicate that the incoming data is valid. Once asserted, it is expected to stay asserted as the data must be streamed to the link layer continuously, unless there is a reset to the system or tx_tl_in_tready_o signal goes low.
tx_tl_in_tready_o	Output	1	Ready signal indicating that the embedded transport layer is ready to accept data.
JESD Tx AXI4 Lite Register Interface **[Clock domain = tx_s_axi_aclk_i]**			
tx_s_axi_aclk_i	Input	1	JESD204B Tx register AXI4-Lite clock interface (50–150 MHz). Refer to the AMBA AXI and ACE Protocol Specification for more information.
tx_s_axi_aresetn_i	Input	1	AXI reset to Tx AXI register, link layer, and transport layer. Resets PHY wrapper PCS and PMA. Refer to the AMBA AXI and ACE Protocol Specification for more information.
tx_s_axi_awaddr_i	Input	32	JESD204B Tx register AXI4-Lite interface ports. Refer to the AMBA AXI and ACE Protocol Specification for more information.
tx_s_axi_awprot_i	Input	3	
tx_s_axi_awvalid_i	Input	1	
tx_s_axi_awready_o	Output	1	
tx_s_axi_wdata_i	Input	32	
tx_s_axi_wstrb_i	Input	4	
tx_s_axi_wvalid_i	Input	1	
tx_s_axi_wready_o	Output	1	
tx_s_axi_bresp_o	Output	2	
tx_s_axi_bvalid_o	Output	1	
tx_s_axi_bready_i	Input	1	
tx_s_axi_araddr_i	Input	32	
tx_s_axi_arprot_i	Input	3	
tx_s_axi_arvalid_i	Input	1	
tx_s_axi_arready_o	Output	1	
tx_s_axi_rdata_o	Output	32	
tx_s_axi_rresp_o	Output	2	
tx_s_axi_rvalid_o	Output	1	
tx_s_axi_rready_i	Input	1	

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Port[1]	Type	Width	Description
JESD Tx Link to PHY Bus Interface [Clock domain = tx_link_clk_i]			
txN_phy_usr_clk_o	Output	1	PHY usr clk to be connected to Tx PHY. Sourced from tx_link_clk_i. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
txN_link_charisk_o	Output	4	Per channel Tx PHY byte control to Tx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
txN_link_data_o	Output	32	Per channel Tx PHY parallel data to Tx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
txN_phy_resetn_o	Output	1	Tx link trigger Tx PHY reset. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
txN_phy_ready_i	Input	1	PHY ready indicator from Tx PHY. Used to reset Tx link. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
JESD Tx PHY to or from Link Bus Interface [Clock domain = txN_phy_user_clk_i]			
txN_phy_clkout_o	Output	1	JESD204B Tx recovered clock out.
txN_phy_usr_clk_i	Input	1	PHY Tx user clock in. Recommended to connect to link layer txN_phy_usr_clk_o. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
txN_phy_charisk_i	Input	4	Per channel Tx PHY byte control input from Tx link. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
txN_phy_data_i	Input	32	Per channel Tx PHY parallel data input from Tx link. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
txN_phy_resetn_i	Input	1	Reset signal from link layer to reset Tx PHY. PHY reset triggered by link layer reset source tx_s_aresetn_i, tx_link_resetn_i, or tx_reg_reset (see note[2]). Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
txN_phy_ready_o	Output	1	Indicates Tx PHY is locked and ready to transmit data. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
JESD Tx PHY Serial Data Interface			
txp_out	Output	NUMBER_OF_LANES	JESD204B Tx serial data out (positive pin)
txn_out	Output	NUMBER_OF_LANES	JESD204B Tx serial data out (negative pin)
JESD Rx Link Layer Interface [Clock domain = rx_link_clk_i]			
rx_link_resetn_i	Input	1	Rx link layer and transport layer reset (active low). Resets PHY wrapper PCS and PMA.
rx_link_clk_i	Input	1	JESD204B link clock to Rx link. Recommended to connect to device clock from an external clock chip which is generating SYSREF.
rx_sysref_i	Input	1	SYSREF input for JESD204B subclass 1 implementation. Tied off for subclass 0. Recommended to generate this signal from an external clock chip which has a matched trace length with the device clock.
rx_sysref_o	Output	1	Retransmit of rx_sysref_i.

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Port[1]	Type	Width	Description
rx_sync_o	Output	1	SYNC output to JESD204B transmitter or converter device. 0 – Synchronization request. 1 – Rx in SYNC and ready for ILAS and data phase.
rx_state_o	Output	2	Indicates Rx link progress. 2'b00 – IDLE stage 2'b01 – CGS in progress 2'b10 – ILAS in progress 2'b11 – User data phase
rx_sof_o	Output	4	Indicates start of frame.
rx_somf_o	Output	4	Indicates start of multiframe.
rx_eof_o	Output	4	Indicates end of frame.
rx_eomf_o	Output	4	Indicates end of multiframe.
rx_aresetn_o	Output	1	Active low reset output. Assert (reset) when JESD core is in reset, PHY is not ready, or Rx reinit register set.
rx_tdata_o	Output	NUMBER_OF_LANES × 32	Rx link data output to external transport layer where four octets are packed into 32-bit data per lane. Channel 0 always start from LSB. Available when *Transport Layer Enable* attribute is unchecked.
rx_tvalid_o	Output	1	Valid signal indicating that the tdata is valid. Available when *Transport Layer Enable* attribute is unchecked.
JESD Rx Embedded Transport Layer Interface (Available when *Transport Layer Enable* attribute is set to checked) **[Clock domain = rx_frame_clk_i]**			
rx_frame_clk_i	Input	1	Frame clock. This clock must be derived from the device clock source in a JESD204B system. The required clock frequency is (Data Rate) / ((F × 10) × (TL_FRAME_PER_CLK)). Refer to the Clock Interface section for more information.
rx_tl_out_tdata_o	Output	ceil((ILA_M+1) × (ILA_S+1) × (ILA_N+1) × TL_FRAME_PER_CLK/ 8) × 8	Output data port for converter samples from embedded transport layer to application layer. Refer to the Embedded Transport Layer section for information.
rx_tl_out_tuser_o	Output	(ILA_M+1) × (ILA_S+1) × (ILA_CS+1) × TL_FRAME_PER_CLK	Output data port for control bits from embedded transport layer to application layer. Refer to the Embedded Transport Layer section for information.
rx_tl_out_tvalid_o	Output	1	Indicates that the data on tdata and tuser bus are valid.
rx_tl_out_tready_i	Input	1	Indicates that the AXI-Stream subordinate is ready to accept data. This signal can be always tied to 1 if the subordinate is always able to accept data.
JESD Rx AXI4 Lite Register Interface **[Clock domain = rx_s_axi_aclk_i]**			
rx_s_axi_aclk_i	Input	1	JESD204B Rx register AXI4-Lite clock interface (50–150 MHz). Refer to the AMBA AXI and ACE Protocol Specification for more information.
rx_s_axi_aresetn_i	Input	1	AXI reset to Rx AXI register, link layer, and transport layer. Resets PHY wrapper PCS and PMA. Refer to the AMBA AXI and ACE Protocol Specification for more information.
rx_s_axi_awaddr_i	Input	32	JESD204B Rx register AXI4-Lite interface ports. Refer to the AMBA AXI and ACE Protocol Specification for more information.
rx_s_axi_awprot_i	Input	3	
rx_s_axi_awvalid_i	Input	1	
rx_s_axi_awready_o	Output	1	
rx_s_axi_wdata_i	Input	32	

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Port[1]	Type	Width	Description
rx_s_axi_wstrb_i	Input	4	
rx_s_axi_wvalid_i	Input	1	
rx_s_axi_wready_o	Output	1	
rx_s_axi_bresp_o	Output	2	
rx_s_axi_bvalid_o	Output	1	
rx_s_axi_bready_i	Input	1	
rx_s_axi_araddr_i	Input	32	
rx_s_axi_arprot_i	Input	3	
rx_s_axi_arvalid_i	Input	1	
rx_s_axi_arready_o	Output	1	
rx_s_axi_rdata_o	Output	32	
rx_s_axi_rresp_o	Output	2	
rx_s_axi_rvalid_o	Output	1	
rx_s_axi_rready_i	Input	1	
JESD Rx Link to or from PHY Bus Interface [Clock domain = rx_link_clk_i]			
rxN_link_charisk_i	Input	4	Per channel Rx PHY byte control from Rx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_link_data_i	Input	32	Per channel Rx PHY parallel data from Rx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_link_disperr_i	Input	4	Disparity error indicator from Rx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_link_notintable_i	Input	4	Not in table error indicator from Rx PHY. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_phy_ready_i	Input	1	PHY ready indicator from Rx PHY. Used to reset Rx link. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_phy_usr_clk_o	Output	1	PHY usr clk to be connected to Rx PHY. Sourced from rx_link_clk_i. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_phy_resetn_o	Output	1	Rx link trigger PHY reset. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
rxN_phy_encommaalign_o	Output	1	Rx link enable PHY comma alignment. PHY comma alignment occurs during the PHY initialization stage. Available when *JESD204 PHY Generation Enable* attribute is set to unchecked.
JESD Rx PHY to Link Bus Interface [Clock domain = rxN_phy_usr_clk_i]			
rxN_phy_clkout_o	Output	1	JESD204B Rx recovered clock out.
rxN_phy_data_o	Output	32	Per channel Rx PHY parallel data out to link. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_charisk_o	Output	4	Per channel Rx PHY byte control out to link. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_disperr_o	Output	4	Indicates per byte disparity error. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.

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Port[1]	Type	Width	Description
rxN_phy_notintable_o	Output	4	Indicates per error when data not in 8b10 encoding table. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_ready_o	Output	1	Indicates Rx PHY is locked and ready to receive external data. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_resetn_i	Input	1	Reset signal from link layer to reset Rx PHY. PHY reset trigger by link layer reset source rx_s_aresetn_i, rx_link_resetn_i, or rx_reg_reset (see note[2]). Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_encommaalign_i	Input	1	To enable PHY comma alignment from link layer. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
rxN_phy_usr_clk_i	Input	1	PHY Rx user clock in. Recommended to connect to link layer rxN_phy_usr_clk_o. Available when *JESD204 IP Core Generation Enable* attribute is set to unchecked.
JESD Rx PHY Serial Data Interface			
rxp_in	Input	NUMBER_OF_LANES	JESD204B Rx serial data in (positive pin)
rxn_in	Input	NUMBER_OF_LANES	JESD204B Rx serial data in (negative pin)
AXI-Lite to PHY LMMI Interface [Clock domain = axil_lmmi_aclk_i]			
axil_lmmi_aresetn_i	Input	1	AXI reset to PHY LMMI interface (active low). Resets PHY LMMI interface.
axil_lmmi_aclk_i	Input	1	AXI4-L clock to LMMI interface (LMMI AXI clock source). CertusPro-NX: 50–150 MHz Avant-G/X and Certus-N2: 100 MHz
axil_lmmi_awvalid_N_i	Input	1	AXI4 Lite to LMMI interface ports (per channel). Refer to AMBA AXI Protocol Specification document for AXI4 Lite Protocol specification. Refer to AXI4-Lite to LMMI for AXI4 Lite to LMMI conversion information. For Avant-G/X and Certus-N2 devices, follow the Byte Offset values (LMMI address in Word size x 2) given in the Lattice Avant SERDES/PCS User Guide (FPGA-TN-02313) and Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395), respectively, for the axil_lmmi_awaddr_N_i and axil_lmmi_araddr_N_i signals.
axil_lmmi_awready_N_o	Output	1	
axil_lmmi_awaddr_N_i	Input	9	
axil_lmmi_awprot_N_i	Input	3	
axil_lmmi_wvalid_N_i	Input	1	
axil_lmmi_wready_N_o	Output	1	
axil_lmmi_wdata_N_i	Input	32	
axil_lmmi_wstrb_N_i	Input	4	
axil_lmmi_bvalid_N_o	Output	1	
axil_lmmi_bready_N_i	Input	1	
axil_lmmi_bresp_N_o	Output	2	
axil_lmmi_arvalid_N_i	Input	1	
axil_lmmi_arready_N_o	Output	1	
axil_lmmi_araddr_N_i	Input	9	
axil_lmmi_arprot_N_i	Input	3	
axil_lmmi_rvalid_N_o	Output	1	
axil_lmmi_rready_N_i	Input	1	
axil_lmmi_rdata_N_o	Output	32	
axil_lmmi_rresp_N_o	Output	2	

Notes:

1. For the CertusPro-NX device, N in port names represents the channel number (for example, 0, 1, 2, or 3). For the Avant-G/X and Certus-N2 devices, N in the port names represents the quad number (for example, quad 0 for channels 0 to 3 and quad 1 for channels 4 to 7).

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2. When the PHY is in Rx_and_Tx mode, both txN_phy_resetn_i and rxN_phy_resetn_i must be asserted to reset the PMA and PCS. Otherwise, only the PCS is reset. When the PHY is in Rx_only or Tx_only mode, asserting rx_phy_resetn_i or tx_phy_resetn_i, respectively, resets both the PMA and PCS.

4.2. Clock Interface

Table 4.2. Clock Ports

Port[1]	Type	Width	Description
PHY Layer for CertusPro-NX			
phy_clkin_i	Input	1	PHY MPCS CLKIN. Recommended frequency is 100–162 MHz.
sd_ext_0_refclkp_i	Input	1	MPCS PHY PMA REFCLK source from external REFCLK 0[2]. Available when *PMA Reference Clock* is set to sd_ext_0_refclk**.** Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sd_ext_0_refclkn_i	Input	1	MPCS PHY PMA REFCLK source from external REFCLK 0[2]. Available when *PMA Reference Clock* is set to sd_ext_0_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sd_ext_1_refclkp_i	Input	1	MPCS PHY PMA REFCLK source from external REFCLK 1[2]. Available when *PMA Reference Clock* is set to sd_ext_1_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sd_ext_1_refclkn_i	Input	1	MPCS PHY PMA REFCLK source from external REFCLK 1[2]. Available when *PMA Reference Clock* is set to sd_ext_1_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sdq_refclkp_q0_i	Input	1	MPCS PHY PMA REFCLK source from Quad 0 REFCLK[2]. Available when *PMA Reference Clock* is set to sdq0_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sdq_refclkn_q0_i	Input	1	MPCS PHY PMA REFCLK source from Quad 0 REFCLK[2]. Available when *PMA Reference Clock* is set to sdq0_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sdq_refclkp_q1_i	Input	1	MPCS PHY PMA REFCLK source from Quad 1 REFCLK[2]. Available when *PMA Reference Clock* is set to sdq1_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
sdq_refclkn_q1_i	Input	1	MPCS PHY PMA REFCLK source from Quad 1 REFCLK[2]. Available when *PMA Reference Clock* is set to sdq1_refclk. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
pll_0_refclk_i	Input	1	MPCS PHY PMA REFCLK source from GPLL0[2]. Available when PMA Reference Clock is set to pclk0. Using a clock source from GPLL to PHY REFCLK is not recommended[3]. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.

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Port[1]	Type	Width	Description
pll_1_refclk_i	Input	1	MPCS PHY PMA REFCLK source from GPLL1[2]. Available when *PMA Reference Clock* is set to pclk1. Using a clock source from GPLL to PHY REFCLK is not recommended[3]. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse.
PHY Layer for Avant-G/X and Certus-N2			
refclk_p_i	Input	1	Quad reference clock, positive polarity. Recommended to generate this signal from an external clock chip which has a matched trace length with link_clk and SYSREF pulse. The reference clock frequency must match the *Ref Clk Freq* attribute.
refclk_n_i	Input	1	Quad reference clock, negative polarity.
PHY Layer across All Devices			
axil_lmmi_aclk_i	Input	1	AXI4-Lite clock to LMMI interface. CertusPro-NX: 50–150 MHz Avant-G/X and Certus-N2: 100 MHz
txN_phy_clkout_o	Output	1	Tx PHY recovered clock. Output frequency is Data Rate / 40 bits. Use this clock out as the Tx link clock if needed. If more than one channel is enabled, use the main channel clock out as the link clock.
txN_phy_usr_clk_i	Input	1	Tx PHY user clock input. Clock source from Tx link layer output txN_phy_usr_clk_o, which is connected to the Tx link clock within the Tx link layer.
rxN_phy_clkout_o	Output	1	Rx PHY recovered clock. Output frequency is Data Rate / 40 bits. Use this clock out as the Rx link clock if needed. If more than one channel is enabled, use the main channel clock out as the link clock.
rxN_phy_usr_clk_i	Input	1	Rx PHY user clock input. Clock source from Rx link layer output rxN_phy_usr_clk_o, which is connected to the Rx link clock within the Rx link layer.
Link and Transport Layer			
tx_link_clk_i	Input	1	JESD204B Tx link clock. Recommended clock source from Tx PHY recovered clock txN_phy_clkout_o. Connect to the main channel if more than one channel is enabled.
rx_link_clk_i	Input	1	JESD204B Rx link clock. Recommended clock source from Rx PHY recovered clock rxN_phy_clkout_o. Connect to the main channel if more than one channel is enabled.
tx_s_axi_aclk_i	Input	1	AXI4-Lite clock Tx register interface (50–150 MHz).
rx_s_axi_aclk_i	Input	1	AXI4-Lite clock Rx register interface (50–150 MHz).
txN_phy_usr_clk_o	Output	1	Tx PHY user clock output from Tx link. Clock source to Tx link output txN_phy_usr_clk_i. Source from tx_link_clk_i.
rxN_phy_usr_clk_o	Output	1	Rx PHY user clock output from Rx link. Clock source to Rx link output rxN_phy_usr_clk_i. Source from rx_link_clk_i.
tx_frame_clk_i	Input	1	JESD204B Tx frame clock into embedded transport layer. This clock must be derived from a common clock source in a JESD204B system. The required clock frequency is: (Data Rate) / ((F × 10) × (TL_FRAME_PER_CLK)). **Note:** F = actual number of octets per frame (not attribute setting or register value).

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Port[1]	Type	Width	Description
			Note: For CertusPro-NX devices, the maximum supported frequency for the Tx frame clock is 185 MHz for the 7_High-Performance_1.0V speed grade and all low power devices.
rx_frame_clk_i	Input	1	JESD204B Rx frame clock into embedded transport layer. This clock must be derived from a common clock source in a JESD204B system. The required clock frequency is: (Data Rate) / ((F × 10) × (TL_FRAME_PER_CLK)). **Note:** F = actual number of octets per frame (not attribute setting or register value). **Note:** For CertusPro-NX devices, the maximum supported frequency for the Rx frame clock is 185 MHz for the 7_High-Performance_1.0V speed grade and all low power devices.

Notes:

1. N in port names represents channel number (for example, 0, 1, 2, or 3).
2. REFCLK frequency is a value between 74.25 and 162 MHz. Refer to MPCS Module – Lattice Radiant Software User Guide (FPGA-IPUG-02118) for more information.
3. Refer to CertusPro-NX SerDes/PCS User Guide (FPGA-TN-02245) for more information.

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5. Register Description

All registers are accessed through the AXI4-Lite interface. Table 5.1 defines the register access types.

Table 5.1. Register Access Types

Access Type	Access Type Abbreviation	Behavior on Read Access	Behavior on Write Access
Read only	RO	Returns register value	Ignores write access
Write only	WO	Returns 0	Updates register value
Read and write	RW	Returns register value	Updates register value
Read and write 1 to clear	RW1C	Returns register value	Writing 1'b1 on register bit clears the bit to 1'b0. Writing 1'b0 on register bit is ignored.
Reserved	RSVD	Returns 0	Ignores write access

5.1. Tx Register

5.1.1. Tx Register Map Overview

Table 5.2. Tx Register Map Overview

Offset	Name	Description
0x00–0x03	Control Register	Tx IP control register
0x04–0x07	Status Register	Tx IP status register
0x08–0x0B	Reserved	Reserved
0x0C–0x0F	Test Mode Register	Tx IP test mode register
0x10–0x13	Link Config 0 Register	Tx IP link configuration register
0x14–0x17	Link Config 1 Register	Tx IP link configuration register
0x18–0x1B	Link Config 2 Register	Tx IP link configuration register
0x1C–0x1F	Link Config 3 Register	Tx IP link configuration register
0x20–0x23	Link Config 4 Register	Tx IP Link Configuration Register
0x24–0x27	Link Config 5 Register	Tx IP Link Configuration Register
0x28–0x2B	Link Config 6 Register	Tx IP Link Configuration Register
0x2C–0x2F	Link Config 7 Register	Tx IP Link Configuration Register

5.1.2. Control Register

Table 5.3. Tx Control Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:16]	LMFC Buffer Adjust	To delay LMFC buffering. Configuring this register delays SOMF-SOF-EOF-EOMF. This register needs to be configured before the first SYSREF trigger.	RW	0
[15:10]	Reserved	Reserved	RO	0
[9]	SYSREF Mask	To mask incoming SYSREF. 0 – Unmask incoming SYSREF 1 – Mask incoming SYSREF SYSREF mask needs to be enabled before the first SYSREF trigger.	RW	0

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Field	Name	Description	Access	Default
[8]	SYSREF Always Enable	Indicates incoming SYSREF is in one-shot or periodic mode. 0 – SYSREF one-shot mode 1 – SYSREF always mode	RW	SYSREF_ Always attribute mode set in GUI
[7:1]	Reserved	Reserved	RO	0
[0]	Tx Core Reset	Tx Core reset. 0 – Release reset 1 – Reset JESD IP Tx core	RW	0

5.1.3. Status Register

Table 5.4. Tx Status Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[15:8]	SYSREF Mismatch Counter	Number of SYSREF period mismatches detected. Read this offset to reset the counter. SYSREF mismatch detection is only enabled in the SYSREF always mode.	RO	0
[7:4]	Reserved	Reserved	RO	0
[3]	PHY Ready	Indicates that PHY calibration is done and ready to accept SYSREF.	RO	0
[2]	SYSREF Captured	Indicates SYSREF detected and captured.	RO	0
[1:0]	TX Link State	Indicates the Tx link state. 2'b00 – IDLE state 2'b01 – CGS state 2'b10 – ILA state 2'b11 – User data state	RO	0

5.1.4. Test Mode Register

Table 5.5. Tx Test Mode Register

Field	Name	Description	Access	Default
[31:3]	Reserved	Reserved	RO	0
[2:0]	Test Pattern Select	Selects the test pattern[1]. 3'b000 – Tx user data from tx_tdata input 3'b001 – Continuous K28.5 pattern 3'b010 – Continuous D21.5 pattern 3'b011 – RPAT pattern 3'b100 – JSPAT pattern	RW	0

Note:

1. When the K28.5 pattern is selected, the JESD204B Tx continuously outputs K28.5 characters without the regular JESD CGS-ILA sequence. When other test patterns are selected, the JESD204B Tx must comply with the regular JESD CGS-ILA sequence before transmitting the test pattern.

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5.1.5. Link Config Register

5.1.5.1. Link Config 0 Register

Table 5.6. Tx Link Config 0 Register

Field	Name	Description	Access	Default
[31]	ILA_SCR	Enables or disables the scrambler[1]. 1 – Enables Tx scrambler 0 – Disables Tx scrambler	RW	Scrambling mode set in GUI
[30:29]	Reserved	Reserved	RO	0
[28:24]	ILA_L	Number of lanes per converter device (link)[2]. If number of lanes is 4, ILA_L value is 5'd3. If number of lanes is 8, ILA_L value is 5'd7.	RO	(NUMBER_OF_LANES attribute value set in GUI) – 1
[23]	Reserved	Reserved	RO	0
[22]	ILA_ADJDIR	Direction to adjust DAC LMFC.	RO	ILA_ADJDIR attribute value set in GUI
[21]	ILA_PHADJ	Phase adjustment request to converter device.	RO	ILA_PHADJ attribute value set in GUI
[20:16]	Reserved	Reserved	RO	0
[15:12]	ILA_ADJCNT	Number of adjustment resolution steps to adjust DAC LMFC.	RO	ILA_ADJCNT attribute value set in GUI
[11:8]	ILA_BID	Bank ID – Extension to DID	RO	ILA_BID attribute value set in GUI
[7:0]	ILA_DID	Device (= link) identification number.	RO	ILA_DID attribute value set in GUI

Notes:

1. The scrambler is always disabled in the CGS and ILA phases.
2. The configured number of lanes shall not exceed the *Number of Lanes* configured in the IP GUI.

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5.1.5.2. Link Config 1 Register

Table 5.7. Tx Link Config 1 Register

Field	Name	Description	Access	Default
[31:30]	ILA_CS	Number of control bits per sample.	RO	Control Bits attribute value set in GUI
[29]	Reserved	Reserved	RO	0
[28:24]	ILA_N	Converter resolution. 5'd0 – Converter resolution is 1 bit 5'd1 – Converter resolution is 2 bits … 5'd31 – Converter resolution is 32 bits	RO	Converter Resolution attribute value set in GUI
[23:16]	ILA_M	Number of converters per device. 8'd0 – 1 converter per device 8'd1 – 2 converters per device … 8'd255 – 256 converters per device	RO	Converters per Device attribute set in GUI
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_K	Number of frames per multiframe. 5'd0 – 1 frame per multiframe 5'd1 – 2 frames per multiframe … 5'd31 – 32 frames per multiframe	RO	Frames per Multiframe attribute value set in GUI
[7:0]	ILA_F	Number of octets per frame. 8'd0 – 1 octet per frame 8'd1 – 2 octets per frame … 8'd255 – 256 octets per frame	RO	Octets per Frame attribute value set in GUI

5.1.5.3. Link Config 2 Register

Table 5.8. Tx Link Config 2 Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[23]	ILA_HD	High density format	RO	High Density Format attribute value set in GUI
[22:21]	Reserved	Reserved	RO	0
[20:16]	ILA_CF	Number of control words per frame clock period per link.	RO	Control Words attribute value set in GUI
[15:13]	ILA_JESDV	JESD204 version. 000 – JESD204A 001 – JESD204B	RO	ILA_JESDV attribute value set in GUI

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Field	Name	Description	Access	Default
[12:8]	ILA_S	Number of samples per converter per frame cycle. 5'd0 – 1 sample per converter 5'd1 – 2 samples per converter … 5'd31 – 32 samples per converter	RO	Samples per Converter per Frame attribute value set in GUI
[7:5]	ILA_SUBCLASSV	Device subclass version. 3'b000 – Subclass 0 3'b001 – Subclass 1	RO	Subclass attribute value set in GUI
[4:0]	ILA_Nt	Total number of bits per sample. 5'd0 – 1 bit per sample 5'd1 – 2 bits per sample … 5'd31 – 32 bits per sample	RO	Number of Bits per Sample attribute value set in GUI

5.1.5.4. Link Config 3 Register

Table 5.9. Tx Link Config 3 Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[23:16]	Multiframes in ILA Sequence	Number of multiframes during ILA sequence. Default (and minimum) is 4 multiframes. 8'd0 to 8'd2 – Not supported 8'd3 – 4 multiframes (default) 8'd4 – 5 multiframes … 8'd127 – 128 multiframes	RO	Multi Frames in ILA attribute value set in GUI
[15:13]	Reserved	Reserved	RO	0
[12:0]	Octets per Multiframe	Number of octets per multiframe. This parameter needs to be updated whenever ILA_F or ILA_K changes. Register value: ((ILA_F+1) × (ILA_K+1)) – 1 Octets per multiframe: ((ILA_F+1) × (ILA_K+1)) **Note:** Register value + 1 must be a multiple of 4. The lowest register value corresponds to the lowest allowable setting. For example, 0 represents 1 octet per multiframe.	RO	(Octets per Frame attribute value set in GUI + 1) × (Frames per Multiframe attribute value set in GUI + 1)

5.1.5.5. Link Config 4 Register

Table 5.10. Tx Link Config 4 Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:24]	ILA_LID_L3	Lane identification number for Lane 3	RO	(ILA_LID attribute value set in GUI + 3) if 4 lanes or more, else 0
[23:21]	Reserved	Reserved	RO	0

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Field	Name	Description	Access	Default
[20:16]	ILA_LID_L2	Lane identification number for Lane 2	RO	(ILA_LID attribute value set in GUI + 2) if 4 lanes or more, else 0
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_LID_L1	Lane identification number for Lane 1	RO	(ILA_LID attribute value set in GUI + 1) if 2 lanes or more, else 0
[7:5]	Reserved	Reserved	RO	0
[4:0]	ILA_LID_L0	Lane identification number for Lane 0	RO	ILA_LID attribute value set in GUI

5.1.5.6. Link Config 5 Register

Table 5.11. Tx Link Config 5 Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:24]	ILA_LID_L7	Lane identification number for Lane 7	RO	(ILA_LID attribute value set in GUI + 7) if 8 lanes, else 0
[23:21]	Reserved	Reserved	RO	0
[20:16]	ILA_LID_L6	Lane identification number for Lane 6	RO	(ILA_LID attribute value set in GUI + 6) if 8 lanes, else 0
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_LID_L5	Lane identification number for Lane 5	RO	(ILA_LID attribute value set in GUI + 5) if 8 lanes, else 0
[7:5]	Reserved	Reserved	RO	0
[4:0]	ILA_LID_L4	Lane identification number for Lane 4	RO	(ILA_LID attribute value set in GUI + 4) if 8 lanes, else 0

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5.1.5.7. Link Config 6 Register

Table 5.12. Tx Link Config 6 Register [Offset 0x28–0x2B]

Field	Name	Description	Access	Default
[31:24]	ILA_FCHK_L3	Lane 3 checksum Σ(all ILA fields)mod 256.	RO	0
[23:16]	ILA_FCHK_L2	Lane 2 checksum Σ(all ILA fields)mod 256.	RO	0
[15:8]	ILA_FCHK_L1	Lane 1 checksum Σ(all ILA fields)mod 256.	RO	0
[7:0]	ILA_FCHK_L0	Lane 0 checksum Σ(all ILA fields)mod 256.	RO	0

5.1.5.8. Link Config 7 Register

Table 5.13. Tx Link Config 7 Register

Field	Name	Description	Access	Default
[31:24]	ILA_FCHK_L7	Lane 7 checksum Σ(all ILA fields)mod 256.	RO	0
[23:16]	ILA_FCHK_L6	Lane 6 checksum Σ(all ILA fields)mod 256.	RO	0
[15:8]	ILA_FCHK_L5	Lane 5 checksum Σ(all ILA fields)mod 256.	RO	0
[7:0]	ILA_FCHK_L4	Lane 4 checksum Σ(all ILA fields)mod 256.	RO	0

5.2. Rx Register

5.2.1. Rx Register Map Overview

Table 5.14. Rx Register Map Overview

Offset	Name	Description
0x00–0x03	Control Register	Rx IP control register
0x04–0x07	Status Register	Rx IP status register
0x08–0x0B	Error Status Register	Rx IP Error Status Register
0x0C–0x0F	Reserved	Reserved
0x10–0x13	Link Config 0 Register	Rx IP Link Configuration Status Register
0x14–0x17	Link Config 1 Register	Rx IP Link Configuration Status Register
0x18–0x1B	Link Config 2 Register	Rx IP Link Configuration Status Register
0x1C–0x1F	Link Config 3 Register	Rx IP Link Configuration Status Register
0x20–0x23	Link Config 4 Register	Rx IP Link Configuration Status Register
0x24–0x27	Link Config 5 Register	Rx IP Link Configuration Status Register
0x28–0x2B	Link Config 6 Register	Rx IP Link Configuration Status Register
0x2C–0x2F	Link Config 7 Register	Rx IP Link Configuration Status Register
0x30–0x33	Error Counter Register	Rx IP Error Counter Register
0x34–0x37	Buffer Fill Level Register	Rx IP Buffer Fill Level Register

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5.2.2. Control Register

Table 5.15. Rx Control Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:16]	LMFC Buffer Adjust	To delay LMFC buffering. Configuring this register delays SOMF-SOF-EOF-EOMF. This register needs to be configured before the first SYSREF trigger. The input value must be less than (Octets per Multiframe – 1) / 4 because four octets are processed every one cycle of internal LMFC.	RW	0
[15:10]	Reserved	Reserved	RO	0
[9]	SYSREF Mask	To mask incoming SYSREF. 0 – Unmask incoming SYSREF 1 – Mask incoming SYSREF SYSREF mask needs to be enabled before the first SYSREF trigger.	RW	0
[8]	SYSREF Always Enable	Indicates incoming SYSREF is in one-shot or periodic mode. 0 – SYSREF one-shot mode 1 – SYSREF always mode	RW	SYSREF_ Always attribute mode set in GUI
[7:2]	Reserved	Reserved	RO	0
[1]	Rx Core Reinitialization	The JESD204B IP reinitializes the Rx core to enter the IDLE stage and deasserts SYNC output (low). Write 1 to de-assert SYNC and reenter IDLE. This bit automatically clears after the write operation.	WO	0
[0]	Rx Core Reset	Rx core reset. 0 – Release reset 1 – Reset JESD IP Rx core	RW	0

5.2.3. Status Register

Table 5.16. Rx Status Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[15:8]	SYSREF Mismatch Counter	Number of SYSREF period mismatches detected. Read this offset to reset the counter. SYSREF mismatch detection is only enabled in the SYSREF always mode.	RO	0
[7:4]	Reserved	Reserved	RO	0
[3]	PHY Ready	Indicates that PHY calibration is done and ready to accept SYSREF.	RO	0
[2]	SYSREF Captured	Indicates SYSREF detected and captured.	RO	0
[1:0]	RX Link State	Indicates the Rx link state. 2'b00 – IDLE state 2'b01 – CGS state 2'b10 – ILA state 2'b11 – User data state	RO	0

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5.2.4. Error Status Register

Table 5.17. Rx Error Status Register

Field	Name	Description	Access	Default
[31]	Reserved	Reserved	RO	0
[30:28]	Error Counter Read Channel Select (ERRCNT_CH_SEL)	Selects which channel's error counter to be read from the Rx error counter register (Rx register offset 0x30). Applies simultaneously to the disparity error, not in table error, and unexpected control character counters.	RW	0
[27:24]	Reserved	Reserved	RO	0
[23:16]	Unexpected Control Character Flag	Unexpected control character (per channel) detected in character replacement since the previous read of this register. The error counter can be read from the Rx error counter register after selecting the channel through ERRCNT_CH_SEL. Write 1 to clear the selected channel counter and this flag. When operating in Subclass 0 mode, the Rx state machine directly enters the DATA phase after one clock cycle in the ILA state. The character replacement block activates from this point of time. If Rx receives ILA data during this period, some of the control characters in the ILA data will be reported as unexpected control character errors. The error count stabilizes after Tx enters the DATA phase.	RW1C	0
[15:8]	Not In Table Error Flag	Not In table error (per channel) detected since the previous read of this register. The error counter can be read from the Rx error counter register after selecting the channel through ERRCNT_CH_SEL. Write 1 to clear the selected channel counter and this flag.	RW1C	0
[7:0]	Disparity Error Flag	Disparity error (per channel) detected since the previous read of this register. The error counter can be read from Rx error counter register after selecting the channel through ERRCNT_CH_SEL. Write 1 to clear the selected counter and this flag.	RW1C	0

5.2.5. Link Config Register

5.2.5.1. Link Config 0 Register

Table 5.18. Rx Link Config 0 Register

Field	Name	Description	Access	Default
[31]	ILA_SCR	Scrambler enable status[1]. 0 – Tx scrambler disabled 1 – Tx scrambler enabled	RO	Scrambling mode set in GUI
[30:29]	Reserved	Reserved	RO	0
[28:24]	ILA_L	Number of lanes per converter device (link)[2]. If number of lanes is 4, ILA_L value is 5'd3. If number of lanes is 8, ILA_L value is 5'd7.	RO	(NUMBER_OF_LANES attribute value set in GUI) – 1
[23]	Reserved	Reserved	RO	0
[22]	ILA_ADJDIR	Direction to adjust DAC LMFC.	RO	ILA_ADJDIR attribute value set in GUI

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Field	Name	Description	Access	Default
[21]	ILA_PHADJ	Phase adjustment request to converter device.	RO	ILA_PHADJ attribute value set in GUI
[20:16]	Reserved	Reserved	RO	0
[15:12]	ILA_ADJCNT	Number of adjustment resolution steps to adjust DAC LMFC.	RO	ILA_ADJCNT attribute value set in GUI
[11:8]	ILA_BID	Bank ID – Extension to DID	RO	ILA_BID attribute value set in GUI
[7:0]	ILA_DID	Device (= link) identification number.	RO	ILA_DID attribute value set in GUI

Notes:

1. The scrambler is always disabled in the CGS and ILA phases.
2. The configured number of lanes shall not exceed the *Number of Lanes* configured in the IP GUI.

5.2.5.2. Link Config 1 Register

Table 5.19. Rx Link Config 1 Register

Field	Name	Description	Access	Default
[31:30]	ILA_CS	Number of control bits per sample.	RO	Control Bits attribute value set in GUI
[29]	Reserved	Reserved	RO	0
[28:24]	ILA_N	Converter resolution. 5'd0 – Converter resolution is 1 bit 5'd1 – Converter resolution is 2 bits … 5'd31 – Converter resolution is 32 bits	RO	Converter Resolution attribute value set in GUI
[23:16]	ILA_M	Number of converters per device. 8'd0 – 1 converter per device 8'd1 – 2 converters per device … 8'd255 – 256 converters per device	RO	Converters per Device attribute value set in GUI
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_K	Number of frames per multiframe. 5'd0 – 1 frame per multiframe 5'd1 – 2 frames per multiframe … 5'd31 – 32 frames per multiframe	RO	Frames per Multiframe attribute value set in GUI
[7:0]	ILA_F	Number of octets per frame. 8'd0 – 1 octet per frame 8'd1 – 2 octets per frame … 8'd255 – 256 octets per frame	RO	Octets per Frame attribute value set in GUI

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5.2.5.3. Link Config 2 Register

Table 5.20. Rx Link Config 2 Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[23]	ILA_HD	High density format	RO	High Density Format attribute value set in GUI
[22:21]	Reserved	Reserved	RO	0
[20:16]	ILA_CF	Number of control words per frame clock period per link	RO	Control Words attribute value set in GUI
[15:13]	ILA_JESDV	JESD204 version. 000 – JESD204A 001 – JESD204B	RO	ILA_JESDV attribute value set in GUI
[12:8]	ILA_S	Number of samples per converter per frame cycle. 5'd0 – 1 sample per converter 5'd1 – 2 samples per converter … 5'd31 – 32 samples per converter	RO	Samples per Converter per Frame attribute value set in GUI
[7:5]	ILA_SUBCLASSV	Device subclass version. 3'b000 – Subclass 0 3'b001 – Subclass 1	RO	Subclass attribute value set in GUI
[4:0]	ILA_Nt	Total number of bits per sample. 5'd0 – 1 bit per sample 5'd1 – 2 bits per sample … 5'd31 – 32 bits per sample	RO	Number of Bits per Sample attribute value set in GUI

5.2.5.4. Link Config 3 Register

Table 5.21. Rx Link Config 3 Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[23:16]	Multiframes in ILA Sequence	Number of multiframes during ILA Sequence. Default (and minimum) is 4 multiframes. 8'd0 to 8'd2 – Not supported 8'd3 – 4 multiframes (default) 8'd4 – 5 multiframes … 8'd127 – 128 multiframes	RW	Multi Frames in ILA attribute value set in GUI
[15:13]	Reserved	Reserved	RO	0

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Field	Name	Description	Access	Default
[12:0]	Octets per MultiFrame	Number of octets per multiframe. This parameter needs to be updated whenever ILA_F or ILA_K changes. Register value: ((ILA_F+1) × (ILA_K+1)) – 1 Octets per multiframe: ((ILA_F+1) × (ILA_K+1)) **Note:** Register value + 1 must be a multiple of 4. The lowest register value corresponds to the lowest allowable setting. For example, 0 represents 1 octet per multiframe.	RW	(Octets per Frame attribute value set in GUI + 1) × (Frames per Multiframe attribute value set in GUI + 1)

5.2.5.5. Link Config 4 Register

Table 5.22. Rx Link Config 4 Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:24]	ILA_LID_L3	Lane identification number for Lane 3	RO	(ILA_LID attribute value set in GUI + 3) if 4 lanes or more, else 0
[23:21]	Reserved	Reserved	RO	0
[20:16]	ILA_LID_L2	Lane identification number for Lane 2	RO	(ILA_LID attribute value set in GUI + 2) if 4 lanes or more, else 0
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_LID_L1	Lane identification number for Lane 1	RO	(ILA_LID attribute value set in GUI + 1) if 2 lanes or more, else 0
[7:5]	Reserved	Reserved	RO	0
[4:0]	ILA_LID_L0	Lane identification number for Lane 0	RO	ILA_LID attribute value set in GUI

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5.2.5.6. Link Config 5 Register

Table 5.23. Rx Link Config 5 Register

Field	Name	Description	Access	Default
[31:29]	Reserved	Reserved	RO	0
[28:24]	ILA_LID_L7	Lane identification number for Lane 7	RO	(ILA_LID attribute value set in GUI + 7) if 8 lanes, else 0
[23:21]	Reserved	Reserved	RO	0
[20:16]	ILA_LID_L6	Lane identification number for Lane 6	RO	(ILA_LID attribute value set in GUI + 6) if 8 lanes, else 0
[15:13]	Reserved	Reserved	RO	0
[12:8]	ILA_LID_L5	Lane identification number for Lane 5	RO	(ILA_LID attribute value set in GUI + 5) if 8 lanes, else 0
[7:5]	Reserved	Reserved	RO	0
[4:0]	ILA_LID_L4	Lane identification number for Lane 4	RO	(ILA_LID attribute value set in GUI + 4) if 8 lanes, else 0

5.2.5.7. Link Config 6 Register

Table 5.24. Rx Link Config 6 Register

Field	Name	Description	Access	Default
[31:24]	ILA_FCHK_L3	Lane 3 checksum Σ(all ILA fields)mod 256.	RO	0
[23:16]	ILA_FCHK_L2	Lane 2 checksum Σ(all ILA fields)mod 256.	RO	0
[15:8]	ILA_FCHK_L1	Lane 1 checksum Σ(all ILA fields)mod 256.	RO	0
[7:0]	ILA_FCHK_L0	Lane 0 checksum Σ(all ILA fields)mod 256.	RO	0

5.2.5.8. Link Config 7 Register

Table 5.25. Rx Link Config 7 Register

Field	Name	Description	Access	Default
[31:24]	ILA_FCHK_L7	Lane 7 checksum Σ(all ILA fields)mod 256.	RO	0
[23:16]	ILA_FCHK_L6	Lane 6 checksum Σ(all ILA fields)mod 256.	RO	0
[15:8]	ILA_FCHK_L5	Lane 5 checksum Σ(all ILA fields)mod 256.	RO	0
[7:0]	ILA_FCHK_L4	Lane 4 checksum Σ(all ILA fields)mod 256.	RO	0

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5.2.6. Error Counter Register

Table 5.26. Rx Error Counter Register

Field	Name	Description	Access	Default
[31:24]	Reserved	Reserved	RO	0
[23:16]	Unexpected Control Character	Unexpected control character error counter during character replacement. Configure ERRCNT_CH_SEL (Rx error status register bit[30:28]) to select which channel's error counter to be read. When operating in Subclass 0 mode, the Rx state machine directly enters the DATA phase after one clock cycle in the ILA state. The character replacement block activates from this point of time. If Rx receives ILA data during this period, some of the control characters in the ILA data will be reported as unexpected control character errors. The error count stabilizes after Tx enters the DATA phase.	RO	0
[15:8]	Not In Table Error Count	Not In table error counter. Configure ERRCNT_CH_SEL (Rx error status register bit[30:28]) to select which channel's error counter to be read.	RO	0
[7:0]	Disparity Error Counter	Disparity error counter. Configure ERRCNT_CH_SEL (Rx error status register bit[30:28]) to select which channel's error counter to be read.	RO	0

5.2.7. Buffer Fill Level Register

Table 5.27. Buffer Fill Level Register

Field	Name	Description	Access	Default
[31:13]	Reserved	Reserved	RO	0
[12:0]	Buffer Fill Level	Buffer fill level in multilane alignment block. This register indicates the buffer fill level from the latest arrival lane (the last lane to exit CGS state) to the release point of internal LMFC counter. Configure LMFC Buffer Adjust (Rx Control Register bit[28:16]) to manipulate the release point. For example, if the current octets per multiframe is set to 128 and the IP processes four octets per clock cycle, the LMFC counter cycles through a maximum value of 128 / 4 = 32 (*Max LMFC count value*). Consequently, the buffer fill level must remain below this threshold. To control the release point, read this register when the core is in the DATA state following initial power up. As an example, if the observed fill level is 30, configure LMFC Buffer Adjust register to 6. The expected fill level after the next reset is calculated as follows: Fill Level = (30 + 6) – 32 = 4 It is recommended that the buffer fill level stay above 2 but below *Max LMFC count value – 2* to account for temperature or process variation. **Note:** The subtraction of 32 accounts for the circular nature of the LMFC counter.	RO	0

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6. Example Design

Lattice provides example designs for simulation and hardware validation. For simulation, an example design is available through the simulation testbench for you to compile, simulate, and test the JESD204B IP. Refer to the Running Functional Simulation section for more information. For hardware validation, the example designs allow you to compile and test the JESD204B IP on the following evaluation boards:

- CertusPro-NX Evaluation Board
- Avant-X Versa Board

6.1. CertusPro-NX Device Example Design

This section shows an example design to validate the JESD204B IP in the CertusPro-NX device using the CertusPro-NX Evaluation Board and ADI ADRV9009 Dual RF Evaluation Board. The design is configured to run at a lane rate of 4.9152 Gb/s with four Tx lanes and two Rx lanes being used.

6.1.1. Example Design Supported Configuration

Table 6.1. JESD204B IP Configuration Supported by the CertusPro-NX Device Example Design

JESD204B IP GUI Parameter	JESD204B IP configuration in example demo design		
	JESD PHY	JESD Tx	JESD Rx
General			
JESD204 IP Core Generation Enable	Unchecked	Checked	Checked
Mode	Rx_and_Tx	Tx_only	Rx_only
Data Rate (Gb/s)	4.9152	4.9152	4.9152
Number of Lanes (L)	4	4	2
Converters per Device (M)	—	3	3
Samples per Converter per Frame (S)	—	0	0
Converter Resolution (N)	—	15	15
Number of Bits per Sample (Nt)	—	15	15
Control Bits (CS)	—	0	0
Control Words (CF)	—	0	0
High Density Format (HD)	—	0	0
Octets per Frame (F)	—	1	3
Frames per Multiframe (K)	—	31	31
Multi Frames in ILA	—	3	3
Subclass (SUBCLASSV)	—	1	1
SYSREF Always	—	SYSREF_ONCE	SYSREF_ONCE
Scrambling (SCR)	—	DISABLED	DISABLED
ILA_DID	—	85	85
ILA_ADJCNT	—	0	0
ILA_BID	—	0	0
ILA_ADJDIR	—	0	0
ILA_PHADJ	—	0	0
ILA_JESDV	—	1	1
ILA_LID	—	0	0
PHY Settings			
JESD204 PHY Generation Enable	Checked	Unchecked	Unchecked

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JESD204B IP GUI Parameter	JESD204B IP configuration in example demo design		
	JESD PHY	JESD Tx	JESD Rx
Lane ID	0	—	—
PMA Reference Clock	sd_ext_1_refclk	—	—
Ref Clk Freq (MHz)	122.88	—	—
PMA Clock Divider	1	—	—
PLL M Settings	2	—	—
Optional Features			
Transport Layer Enable	Unchecked	Checked	Checked
Frame per Clock	—	2	1
Test Mode Enable	Unchecked	Unchecked	Unchecked

6.1.2. Overview of the Example Design and Features

Key features of the example design include:

- Interoperability with ADI ADRV9009 Dual RF Evaluation Board configured to 4T2R (transmitter configured to four lanes, receiver configured to two lanes).
- Lane rate of 4.9152 Gb/s.
- IP core includes an embedded transport layer which allows IQ data to be directly connected to the IP core interface.
- RISC-V MC IP core used to configure ADI ADRV9009 Dual RF Evaluation Board settings through SPI interface, as well as to control or read status from JESD IP instances through AHB and AXI-Lite interfaces.

6.1.3. Example Design Components

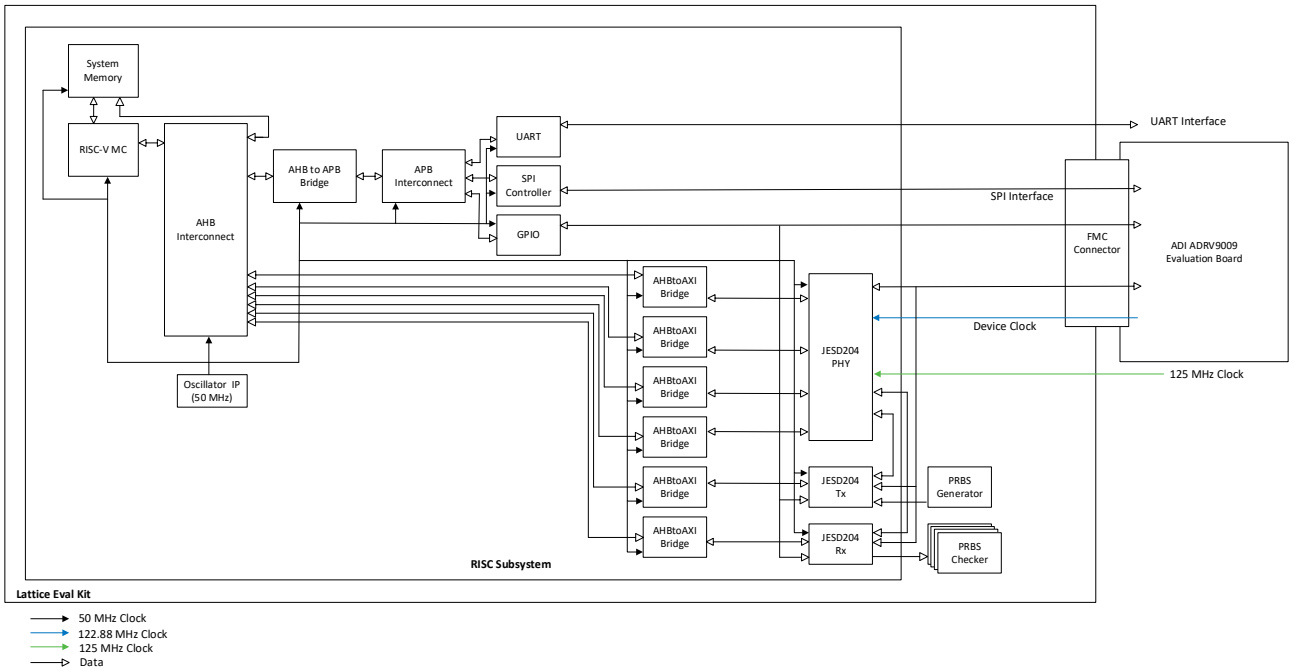


Figure 6.1. JESD204B Example Design Block Diagram

The JESD204B example design includes the following blocks:

- JESD204B Tx
- JESD204B Rx
- JESD204B PHY

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- PRBS Generator
- PRBS Checker
- AHB to AXI Bridge
- RISC subsystem

6.1.3.1. JESD204B Tx

This block receives the IQ data from a PRBS generator and packetizes the data into JESD204B compliant packets before transmitting the data to the JESD204B PHY block. It contains an internal transport layer which can remap the data directly from data converter to the internal core. This block is instantiated separately from the JESD204B Rx block as both have a different configuration in this example design.

6.1.3.2. JESD204B Rx

This block receives the data from the JESD204B PHY block and outputs the sample data to multiple PRBS checkers to check for data correctness. It has an internal transport layer which remaps the data from internal core to the converter's sample format. This block is instantiated separately from the JESD204B Tx block as both have a different configuration in this example design.

6.1.3.3. JESD204B PHY

This block wraps around the SERDES IP of the targeted device family and connects to both the JESD204B Tx and Rx blocks. The function of this block is to serialize the parallel data from the JESD204B Tx and transmit the serial data to an external component, as well as to de-serialize the serial data from an external component and send the parallel data for further processing in the JESD204B Rx block. This block is instantiated separately from the JESD204B Tx and Rx blocks, as Tx and Rx have different core configurations but share the same transceiver channel on the physical port.

6.1.3.4. PRBS Generator

This block generates a PRBS7 data sequence to the IP core.

6.1.3.5. PRBS Checker

Each checker receives the data from the JESD204B Rx block for one converter's samples and performs the PRBS data sequence checking. It makes sure that the data received matches the PRBS7 data sequence and flags an error if any error is detected.

6.1.3.6. AHB to AXI Bridge

This block converts the data from the AHB interconnect data bus in the RISC subsystem and outputs the equivalent transfer on the AXI4 output interface. The AXI4 interfaces are then connected to each AXI4-Lite interface on the JESD204B blocks so that these blocks can be controlled through the RISC-V MC IP module contained in the RISC subsystem.

6.1.3.7. RISC Subsystem

This block is a subsystem that is composed of a RISC-V MC IP, System Memory IP, AHB and APB Interconnect IPs, AHB to APB Bridge IP, UART IP, SPI Controller IP, GPIO IP, and Oscillator IP. All blocks are connected to the RISC-V MC IP, which serves as the central controller of the design. It controls the GPIO and SPI Controller IPs, whose outputs are directly connected to the ADI ADRV9009 Dual RF Evaluation Board through the FMC connector, to power on the daughter card and configure the JESD link and clock chip on the daughter card. It can also control and read the status from the JESD204B PHY, Tx, and Rx blocks and output the log message through the UART terminal.

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6.1.4. Hardware Testing

6.1.4.1. Running the Hardware without Rebuilding the Design

1. Connect the ADI ADRV9009 Dual RF Evaluation Board to the Lattice CertusPro-NX (CPNX) Evaluation Board.
2. Connect a 30.72 MHz clock source to REF_CLK_IN (J401) SMA connector of the ADRV9009 evaluation board.
3. Make sure that the UART debug jumpers (JP1 and JP2) on the CPNX evaluation board are connected with a jumper pin.
4. Connect a USB cable from your PC to the mini-USB connector on the CPNX evaluation board.
5. Unzip the CPNX_EVAL_ADRV9009.zip file from the eval folder within the IP core directory.
6. Open the Radiant Programmer tool.
7. Go to the source directory and locate the impl_1.xcf file.

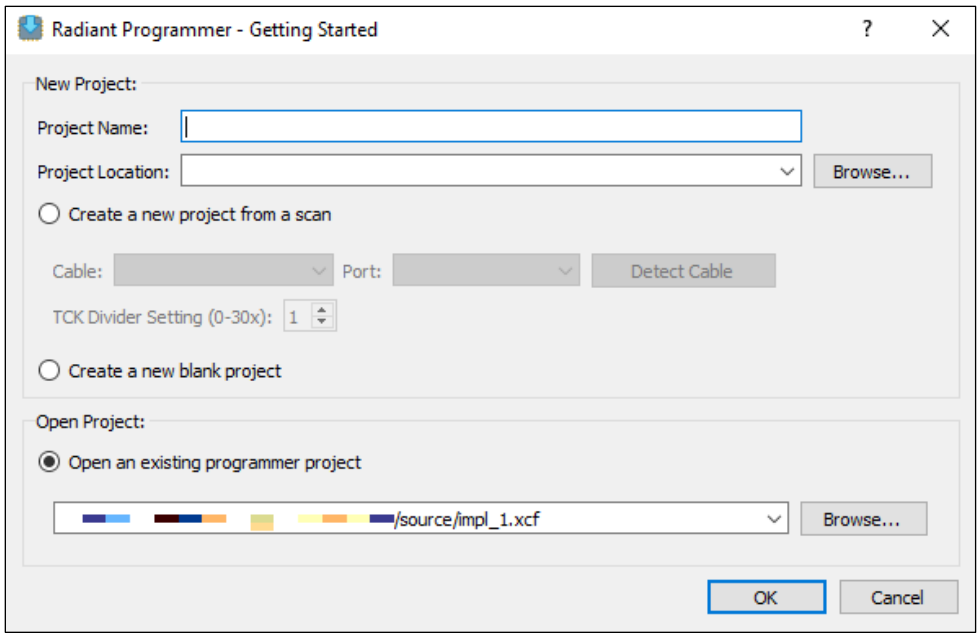


Figure 6.2. Opening a Programmer Project

8. Program the FPGA device with the generated bitstream file.



Figure 6.3. Programming the Device through the Run Menu

You should see seven green LEDs lighting up sequentially. If you have a serial port communication program such as PuTTY, you may also open a terminal to see the log messages. Note that before programming, in PuTTY, set the **Serial line** to the correct value, **Speed** (baud rate) to 115200, and **Connection type** to Serial. Alternatively, you can also use the terminal in Lattice Propel.

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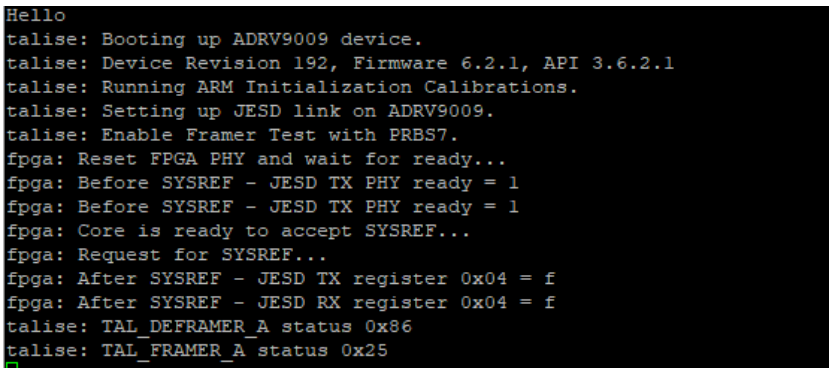


Figure 6.4. Programming Log Messages

Four yellow LEDs should also light up at the end of programming. The LEDs represent different status or signals of the design as summarized in Table 6.2.

Table 6.2. Summary of LED Indicators on CPNX Evaluation Board

Schematic Signal Name	Label On Board	RTL Signal Name	Description
LED_0	D6	led_g_o[0]	SYNC input from ADRV9009. JESD Rx on ADRV9009 has passed the CGS state when the LED lights up.
LED_1	D7	led_g_o[1]	Tx PHY has gone through calibration and is ready when the LED lights up.
LED_2	D8	led_g_o[2]	Tx JESD core is in the user data phase when the LED lights up.
LED_3	D9	led_g_o[3]	TREADY signal from JESD Tx core transport layer. The core is ready to accept user data when the LED lights up.
LED_4	D10	led_g_o[4]	Rx PHY has gone through calibration and is ready when the LED lights up.
LED_5	D11	led_g_o[5]	Rx JESD core is in the user data phase when the LED lights up.
LED_6	D12	led_g_o[6]	TVALID signal from JESD Rx core transport layer. The Rx core is outputting valid samples data when the LED lights up.
LED_7	D13	led_g_o[7]	PRBS checker status. The PRBS checker does not detect any error (for PRBS7 data sequence) in the incoming data stream. This LED is expected to be initially off when led_g_o[6] first lights up. Toggle the SW4 push button to clear the initial PRBS error and this LED should light up if there is no PRBS error detected afterwards.
LED_8	D14	led_y_o[0]	Bit[1] of the JESD Tx core tx_state_o output signal. Serves as a debug signal to determine the state in which the core is stuck when led_g_o[2] does not light up.
LED_9	D15	led_y_o[1]	Bit[0] of the JESD Tx core tx_state_o output signal. Serves as a debug signal to determine the state in which the core is stuck when led_g_o[2] does not light up.
LED_14	D20	led_y_o[6]	Bit[1] of the JESD Rx core rx_state_o output signal. Serves as a debug signal to determine the state in which the core is stuck when led_g_o[5] does not light up.
LED_15	D21	led_y_o[7]	Bit[0] of the JESD Rx core rx_state_o output signal. Serves as a debug signal to determine the state in which the core is stuck when led_g_o[5] does not light up.
LED_23	D29	led_r_o[7]	PRBS checker status. The PRBS checker has detected an error (for PRBS7 data sequence) in the incoming data stream. This LED is expected to light up initially when led_g_o[6] first lights up. Toggle the SW4 push button to clear the initial PRBS error and this LED should be off if there is no PRBS error detected afterwards.

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9. After testing for the desired amount of time to verify the PRBS data sequence, press the SW5 push button to shut down the ADRV9009 evaluation board as well as to assert and hold the reset signals to the JESD IP core blocks. This marks the end of the hardware testing process.

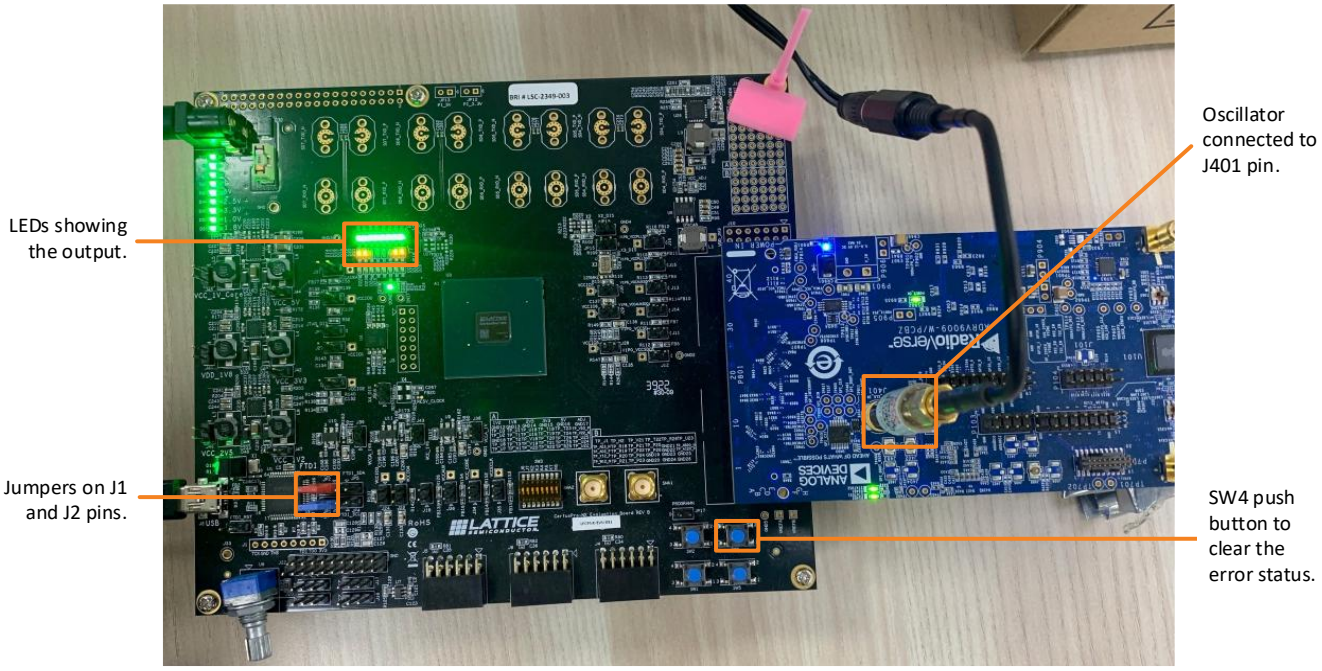


Figure 6.5. CertusPro-NX Evaluation Board (Left) with ADI ADRV9009 Dual RF Evaluation Board (Right)

6.1.4.2. Known Issues

The following are known issues:

- The PRBS checker on the ADI ADRV9009 Dual RF Evaluation Board constantly reports max error count. This is attributed to some issues with the ADI software. Hence, the Tx data transmitted from the FPGA is not being validated currently.
- Pressing the reset button (SW1 push button) does not rerun the main program. The current workaround is to reprogram the bitstream file if you wish to rerun the program.

6.1.4.3. Rebuilding the Design

RISC-V Software

1. Copy the CPNX_EVAL_ADRV9009.zip file from the eval folder within the IP core directory, then paste and unzip the file in your working directory.
2. Go to this ADI page to read and accept the license agreement before proceeding to download the required software.
3. Download the ADRV9008/ADRV9009 Evaluation Software with GUI for Evaluation Board and ADRV9008/ADRV9009 API Source Code. The versions tested are as follows:
   - ADRV9008/ADRV9009 Evaluation Software with GUI for Evaluation Board Ver. 6.0 (3.6.2.1)
   - ADRV9008/ADRV9009 API Source Code Ver. 6.0 (6.2.1)

ADRV9009	ADRV9009/PCBZ	ADRV9008/ADRV9009 Evaluation Software with GUI for Evaluation Board (ZIP) ADRV9008/ADRV9009 API Source Code (ZIP)

Figure 6.6. ADI Software and Source Code to Download

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4. Install the ADRV9008/ADRV9009 Evaluation Software and open the GUI.
5. Click **Connect** on the top left. The GUI shows the ADRV9008/ADRV9009 diagram. Ignore the *Cannot Connect to the Device* error message if it appears.
6. Click **File** and select the **Load GUI Setup** option.
7. From the extracted folder in Step 1, select the cpnx_ed_profile.xml file in the adrv9009_profile folder which loads the target configuration for this example design. A pop-up dialog box appears once the setup loads successfully. The device shown should be ADRV9009.
8. Go to **Tools > Create Script > Init .c Files** to generate some of the necessary software code for the design in the same adrv9009_profile folder. Setup the JESD204B interface as shown in Figure 6.7.

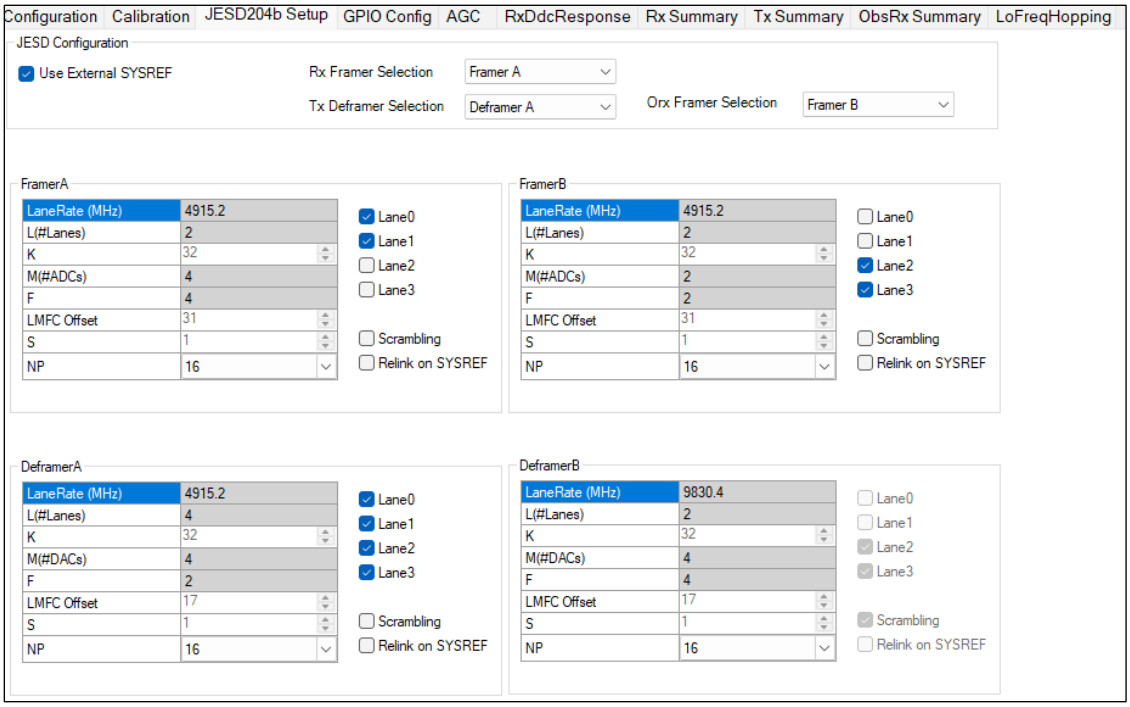


Figure 6.7. JESD204B Setup Information

9. Unzip the downloaded adrv9009-api-source-code.zip file. Locate the software codes required for the design in the API\src\devices folder.

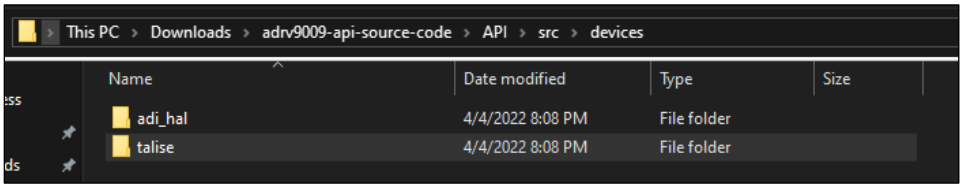


Figure 6.8. Locating the Software Codes

10. Copy the adrv9009-api-source-code folder to the extracted CPNX_EVAL_ADRV9009.zip folder as well. This folder should be at the same level as the adrv9009_profile folder.
11. Open a command prompt terminal and change the directory to the extracted CPNX_EVAL_ADRV9009.zip folder.
12. Run the gitclone_patch.bat file in Windows or gitclone_patch.sh (bash shell script) file in Linux. This downloads the necessary software files from the ADI GitHub page and makes the necessary changes for this design.

    Note: In Windows, ensure the git client software (such as Git Bash) is first installed before running the gitclone_patch.bat file.

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13. After this process is done, open the Lattice Propel software to import the project.
14. Right-click on the Project Explorer tab area and select **Import**. The Import window appears. Expand the General folder and select *Existing Projects into Workspace*.

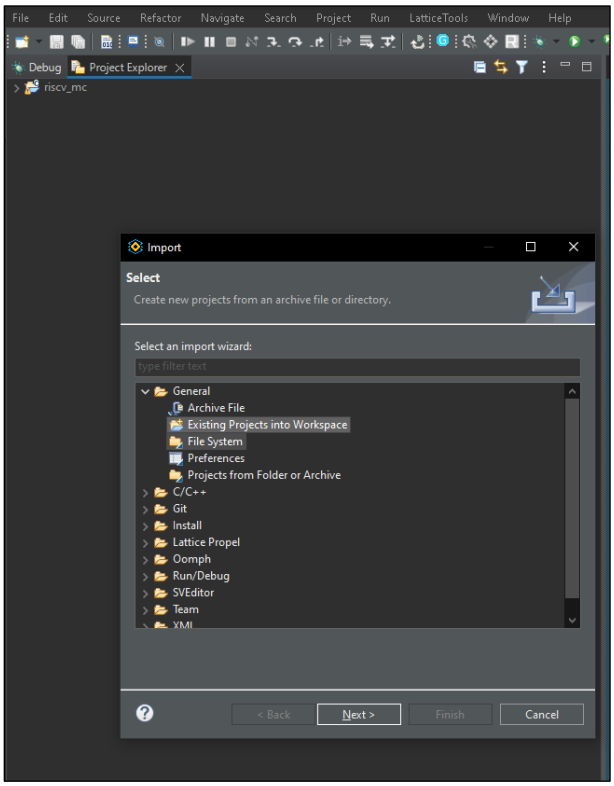


Figure 6.9. Project Explorer Import Window in Propel

15. Browse to the propel_sw folder and select it as your root directory. Click **Finish** to complete importing the project.
16. Right-click on the project folder and select **Build Project** to start building the software. This generates a .mem file in a new Debug folder within the propel_sw folder. This .mem file can be used for initializing the system memory in the design.

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RTL Design

1. Ensure that you have run the gitclone_patch.bat or gitclone_patch.sh file from Step 12 in the RISC-V Software section. Also, ensure that you have a .mem file generated and two RTL files named ad_pngen.v and ad_pnmon.v are present in the CPNX_EVAL_ADRV9009 folder.
2. Open the Lattice Propel Builder program and select **Open Design** from the File tab.
3. Browse to the CPNX_EVAL_ADRV9009/risc_sys folder and select the risc_sys.sbx file to bring up the schematic design of the SoC design.
4. Locate the system memory module as shown in Figure 6.10 and select **Reconfig**. If a newer version of the system memory module is available, click **Yes** to update the IP to proceed.

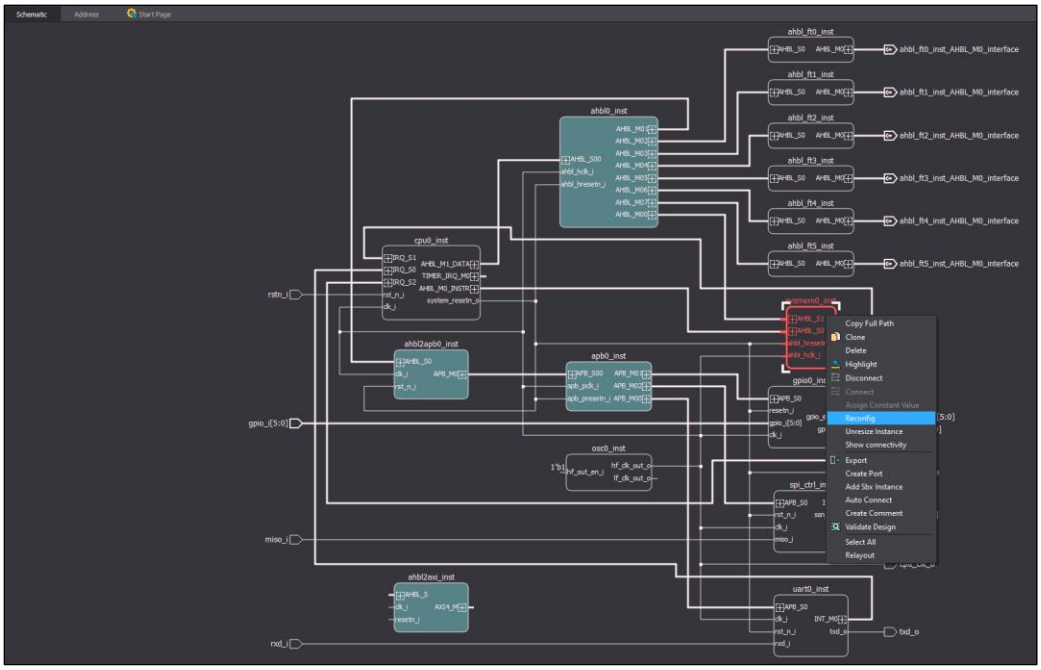


Figure 6.10. Locating System Memory Module and Selecting Reconfig

5. For *Initialization File* attribute, browse to the .mem file (located in the propel_sw/Debug folder) that you generated in the Propel project from Step 16 in the RISC-V Software section. Click **Generate** at the bottom right corner of the IP GUI.

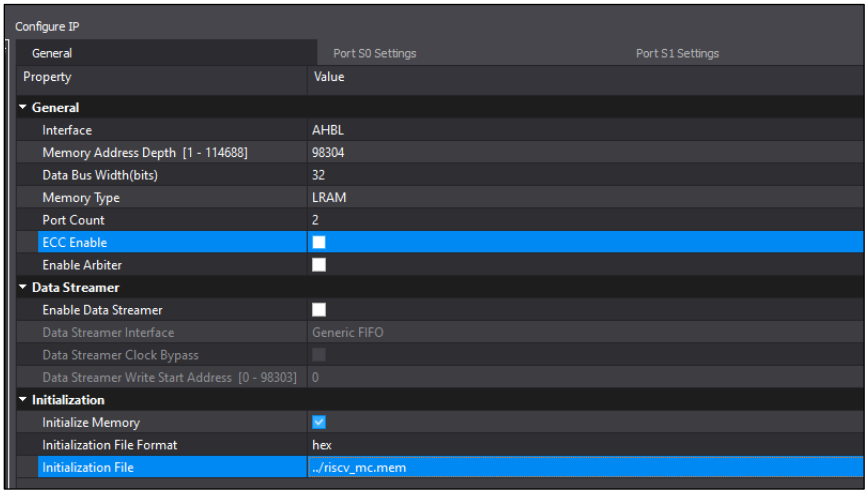


Figure 6.11. Selecting the Initialization File

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6. Next, in the TCL Console, type *source <project directory>/regen_ip_files.tcl* to regenerate RTL files for the other IP components. Make sure the following IP components are installed in your IP catalog before entering the command:
   - AHB-Lite to AXI4 Bridge v1.4.0
   - GPIO v1.8.0
   - SPI Controller v2.4.0
   - UART v1.5.0
   - AHB Lite Interconnect v1.5.0
   - AHB Lite to APB Bridge v1.2.0
   - APB Interconnect v1.4.0

   This ensures the IP versions in regen_ip_files.tcl match the versions of the installed IP components.
7. Select **Design** > **Generate**. This regenerates the wrapper files and software files for the SoC design.

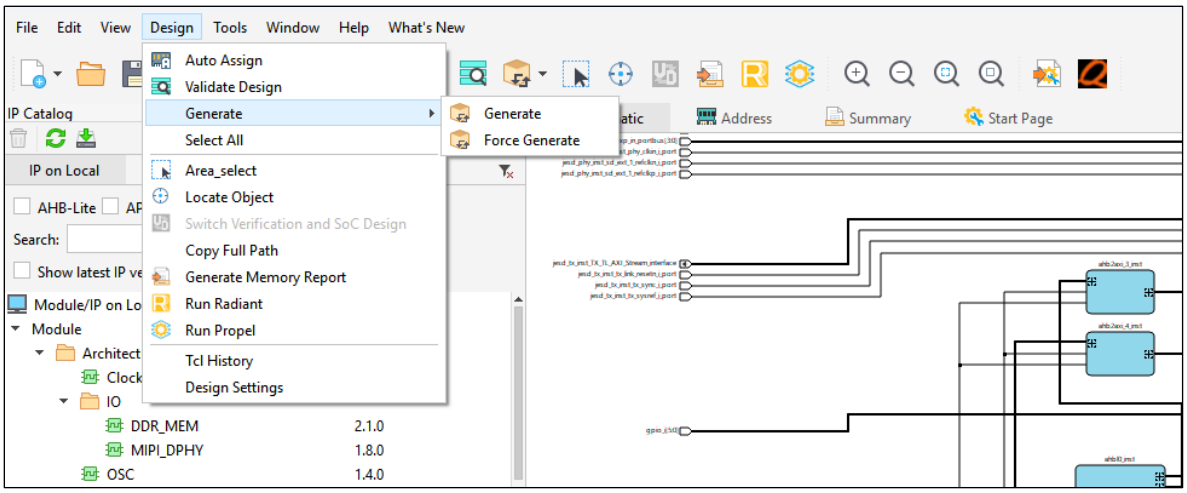


Figure 6.12. Regenerating the SoC Design RTL

8. Open the Radiant software and select **Open Project**.
9. Select the risc_sys.rdf file in the CPNX_EVAL_ADRV9009 folder to open the RTL project.
10. Click the **Play** button at the top left of the GUI to start compiling the design.
11. After compilation has completed, a bitstream file is generated in the impl_1 folder. Follow the steps from Step 8 onwards in the Running the Hardware without Rebuilding the Design section to program the board with the new bitstream file.

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6.2. Avant-X Versa Board Rx Example Design

This section shows an example design to validate the JESD204B IP in the Avant-X device using the Avant-X Versa Board and Texas Instruments (TI) ADC32RF44EVM Evaluation Board (ADC32RF44EVM). The design is configured to run at a data rate of 9.8304 Gb/s with eight lanes.

6.2.1. Example Design Supported Configuration

Table 6.3. JESD204B IP Configuration Supported by the Avant-X Versa Board Rx Example Design

JESD204B IP GUI Parameter	JESD204B IP configuration in example demo design
	JESD Rx + PHY
General	
JESD204 IP Core Generation Enable	Checked
Mode	Rx_only
Data Rate (Gb/s)	9.8304
Number of Lanes (L)	8
Converters per Device (M)	1
Samples per Converter per Frame (S)	19
Converter Resolution (N)	11
Number of Bits per Sample (Nt)	11
Control Bits (CS)	0
Control Words (CF)	0
High Density Format (HD)	0
Octets per Frame (F)	7
Frames per Multiframe (K)	31
Multi Frames in ILA	3
Subclass (SUBCLASSV)	1
SYSREF Always	SYSREF_ALWAYS
Scrambling (SCR)	DISABLED
ILA_DID	85
ILA_ADJCNT	0
ILA_BID	0
ILA_ADJDIR	0
ILA_PHADJ	0
ILA_JESDV	1
ILA_LID	0
PHY Settings	
JESD204 PHY Generation Enable	Checked
Lane ID	0
Ref Clk Freq (MHz)	122.88
Optional Features	
Transport Layer Enable	Checked
Frame per Clock	1
Test Mode Enable	Unchecked

6.2.2. Overview of the Example Design and Features

Key features of the example design include:

- Interoperability with ADC32RF44EVM Evaluation Board configured to eight transmission lanes.
- Lane rate of 9.8304 Gb/s.

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- IP core includes an embedded transport layer which allows IQ data to be directly connected to the IP core interface.
- Example design includes a ramp checker logic that validates incoming ramp signal from the ADC32RF44EVM Evaluation Board.

6.2.3. Example Design Components

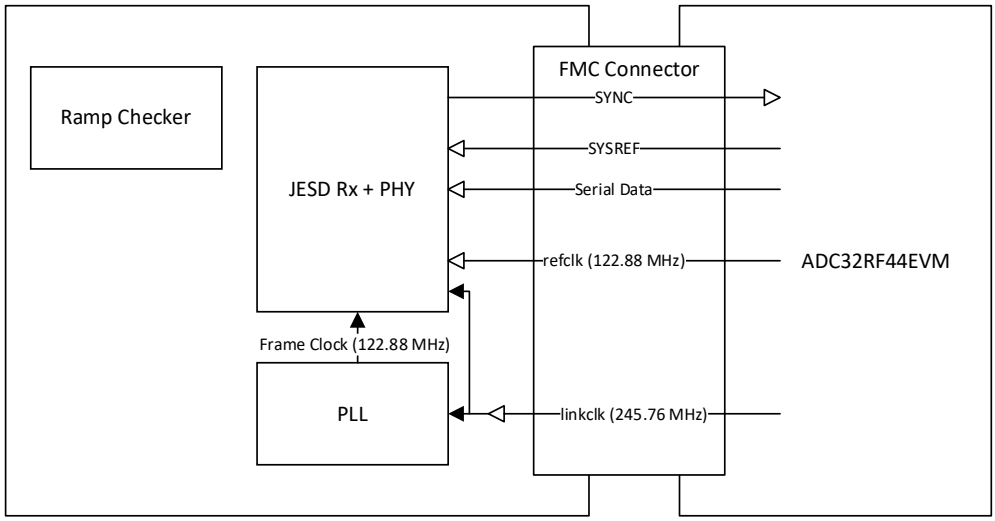


Figure 6.13. JESD204B Example Design Block Diagram (with Avant-X and TI Evaluation Boards)

The JESD204B Rx example design includes the following blocks:

- JESD204B Rx + PHY
- Ramp Checker
- PLL

6.2.3.1. JESD204B Rx + PHY

This block wraps around the serializer/de-serializer (SERDES) IP of the targeted device and connects to both the JESD204B PHY and Rx blocks. The PHY de-serializes the serial data from an external component and sends parallel data for further processing in the JESD204B Rx block. The JESD204B Rx then outputs the sample data to the ramp checkers to check for data correctness. It has an internal transport layer which remaps the data from the internal core to the converter's sample format.

6.2.3.2. Ramp Checker

The JESD configuration is set to M=2, S=20, and N=12. The ramp checker receives sample data as two distinct ramp signals from the JESD204B Rx. The first 20 samples of the 12-bit output carry the ramp signal for channel B while the second 20 samples of the 12-bit output carry the ramp signal for channel A. The ramp signals are expected to increment from the first data N to 12'hFFF before returning to 0. The checker asserts the passed flag once valid data is received from the JESD204B Rx output. If a mismatch is detected, the passed flag is held low until reset.

6.2.3.3. PLL

This block generates the frame clock by dividing the link clock by 2.

6.2.4. Hardware Testing

6.2.4.1. Pre-requisites

- TI ADC32RF44EVM
- TI ADC32RFxxEVM SPI GUI (v4.1)
- Avant-X Versa Board

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6.2.4.2. Generating Bitstream

1. Copy the lav_versa_adc32rf44_8l_9p8g.zip file from the eval folder within the IP core directory, then paste and unzip the file in your working directory.
2. Open the Radiant software and select **Open project**.
3. Select the lav_versa_adc32rf44_8l_9p8g.rdf file from the unzipped directory to open the RTL project.
4. Right-click on any .ipx file and select **Regenerate ALL IPs** to regenerate all IP instances in the design.

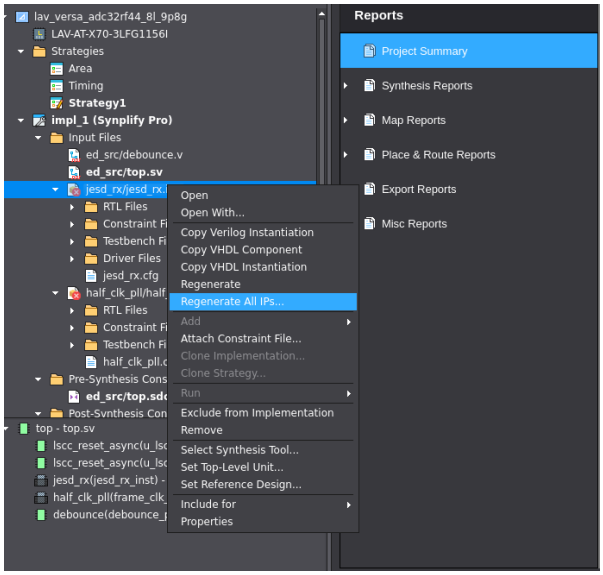


Figure 6.14. Regenerating All IP Instances

5. Click on the **Play** button at the top left of the GUI to start compiling the design. A bitstream file is generated in the impl_1 folder after the compilation process completes.

6.2.4.3. TI ADC32RF44EVM Setup

Because the ADC32RF44EVM provides all the clocks required by the Avant-X Versa Board, you must set up the ADC32RF44EVM before the Avant-X Versa Board.

1. Connect the ADC32RF44EVM to the Avant-X Versa Board.
2. Connect the required power supply to the ADC32RF44EVM.
3. Connect a mini-USB cable between the ADC32RF44EVM and the PC with the ADC32RFxxEVM SPI GUI installed. The GUI installer can be found in the TI ADC32RF45 web page.
4. Configure the ADC32RFxxEVM SPI GUI as follows:
   a. In Quick Setup:
      i. Select LMX2582 as the clock source to ADC.
      ii. Set ADC32RFxx mode to bypass.
      iii. Set resolution to 12-bit. This in turn sets Lanes=8, M=2, F=8, and S=20.
      iv. Internal Clk Freq defaults to 2457.6 Msps.
      v. Click **PROGRAM EVM**.
   b. In LMK04828:
      i. Set *CLKout 0 and 1 FPGA Clock & SYSREF* **DCLK Divider** to 20 to achieve 122.88 MHz for refclk.
      ii. Set *CLKout 12 and 13 Extra FMC Clocks* **DCLK Divider** to 10 to achieve 245.76 MHz for linkclk. Then, set **DCLK Type** to LVDS and uncheck the **Group Powerdown** checkbox.
   c. In Low Level View, go to ADC32RFxx_DIGITAL block in the **Register Name** tab:

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i. Configure the lane mapping registers JESD_DIG_CHA_0x16 and JESD_DIG_CHB_0x16 to 0xF2 by inserting the value and clicking **Write Register** at the bottom right of the window.

ii. Similarly, configure the output to ramp pattern by setting registers JESD_DIG_CHA_0x03 and JESD_DIG_CHB_0x03 to 0x01.

The ADC is now ready to transmit.

6.2.4.4. Avant-X Versa Board Setup

1. Make sure that the JP1 jumper on the Avant evaluation board is connected with a jumper pin to allow configuring from the JTAG port.
2. Connect a USB cable from your PC to the mini-USB connector on the Avant evaluation board.
3. Open the Radiant Programmer tool.
4. Locate the generated bitstream file in the impl_1 folder, then program the FPGA device with the file.
5. Press the SW13 push button to start the ramp checker after both the qsfp_link_led and zsfp1_link_led LEDs light up. Three LEDs on the Avant-X Versa Board (see Figure 6.15) are mapped to the following design statuses. A working design is indicated by all 3 LEDs lighting up.

Table 6.4. Summary of LED Indicators on Avant-X Versa Board (Rx Example Design)

LED	Pin	Description
qsfp_link_led	AN10	jesd_rxphy_ready. Indicates that PHY is up and receiving data from ADC when the LED lights up.
zsfp1_link_led	AJ13	rx_state_o == 2'b11. Indicates that JESD Rx is up and receiving data when the LED lights up.
zsfp2_link_led	AH13	Passed flag from ramp checker. Flag is asserted when the LED lights up.

This marks the end of the hardware testing process.
Note that the SW12 push button is connected as the master reset of the ramp checker, JESD Rx, and PHY. You can reset as needed.

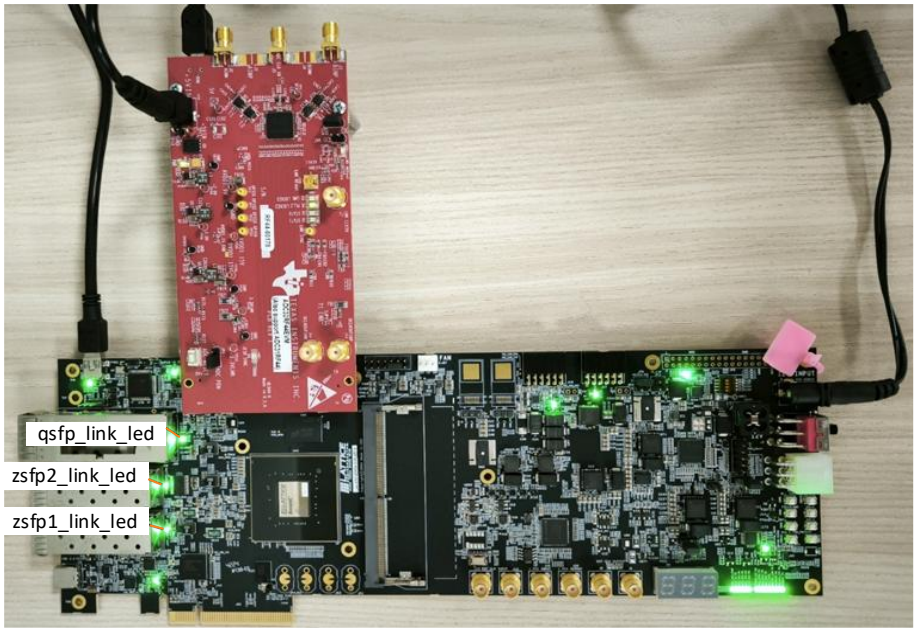


Figure 6.15. Avant Versa Board (Bottom) with TI ADC32RF44EVM Evaluation Board (Top)

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6.3. Avant-X Versa Board Tx Example Design

This section shows an example design to validate the JESD204B IP in the Avant-X device using the Avant-X Versa Board and TI DAC39RF10EVM Evaluation Board (DAC39RF10EVM). The design is configured to run at a data rate of 9.8304 Gb/s with eight lanes.

6.3.1. Example Design Supported Configuration

Table 6.5. JESD204B IP Configuration Supported by the Avant-X Versa Board Tx Example Design

JESD204B IP GUI Parameter	JESD204B IP configuration in example demo design
	JESD Tx + PHY
General	
JESD204 IP Core Generation Enable	Checked
Mode	Tx_only
Data Rate (Gb/s)	9.8304
Number of Lanes (L)	8
Converters per Device (M)	1
Samples per Converter per Frame (S)	3
Converter Resolution (N)	15
Number of Bits per Sample (Nt)	15
Control Bits (CS)	0
Control Words (CF)	0
High Density Format (HD)	0
Octets per Frame (F)	1
Frames per Multiframe (K)	31
Multi Frames in ILA	3
Subclass (SUBCLASSV)	1
SYSREF Always	SYSREF_ALWAYS
Scrambling (SCR)	DISABLED
ILA_DID	85
ILA_ADJCNT	0
ILA_BID	0
ILA_ADJDIR	0
ILA_PHADJ	0
ILA_JESDV	1
ILA_LID	0
PHY Settings	
JESD204 PHY Generation Enable	Checked
Lane ID	0
Ref Clk Freq (MHz)	122.88
Optional Features	
Transport Layer Enable	Checked
Frame per Clock	2
Test Mode Enable	Unchecked

6.3.2. Overview of the Example Design and Features

Key features of the example design include:

- Interoperability with TI DAC39RF10EVM Evaluation Board configured to eight receiving lanes.
- Lane rate of 9.8304 Gb/s.

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- IP core includes an embedded transport layer which allows IQ data to be directly connected to the IP core interface.
- A constant square wave pattern is sent to the DAC for viewing in an external oscilloscope.

6.3.3. Example Design Components

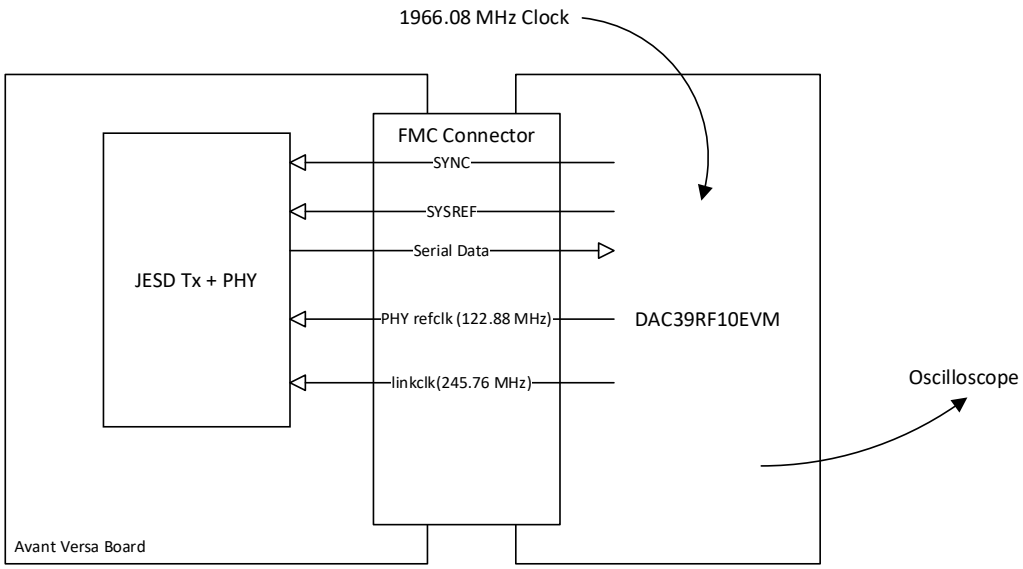


Figure 6.16. JESD204B Example Design Block Diagram (with Avant-X and TI Evaluation Boards)

The JESD204B Tx example design includes the following block:

- JESD204B Tx + PHY

6.3.3.1. JESD204B Tx + PHY

The JESD204B IP receives the IQ data and packetizes the data into JESD204B-compliant packets before transmitting the data to the JESD204B PHY block. It contains an internal transport layer which can remap a square wave pattern to the internal core. The PHY block then serializes the parallel data from the JESD204B Tx and transmits the serial data to an external component.

6.3.4. Hardware Testing

6.3.4.1. Pre-requisites

- TI DAC39RF10EVM
- TI DAC39RF10EVM-GUI (v3.1.2)
- Avant-X Versa Board
- A clock generator that can generate a 1,966.08-MHz clock
- An oscilloscope to observe the output waveform

6.3.4.2. Generating Bitstream

1. Copy the lav_versa_dac39rf10_8l_9p8g.zip file from the eval folder within the IP core directory, then paste and unzip the file in your working directory.
2. Open Radiant software and select **Open project**.
3. Select the lav_versa_dac39rf10.rdf file from the unzipped directory to open the RTL project.
4. Right-click on any .ipx file and select **Regenerate All IPs** to regenerate all IP instances in the design.
5. Click on the **Play** button at the top left of the GUI to start compiling the design. A bitstream file is generated in the impl_1 folder after the compilation process completes.

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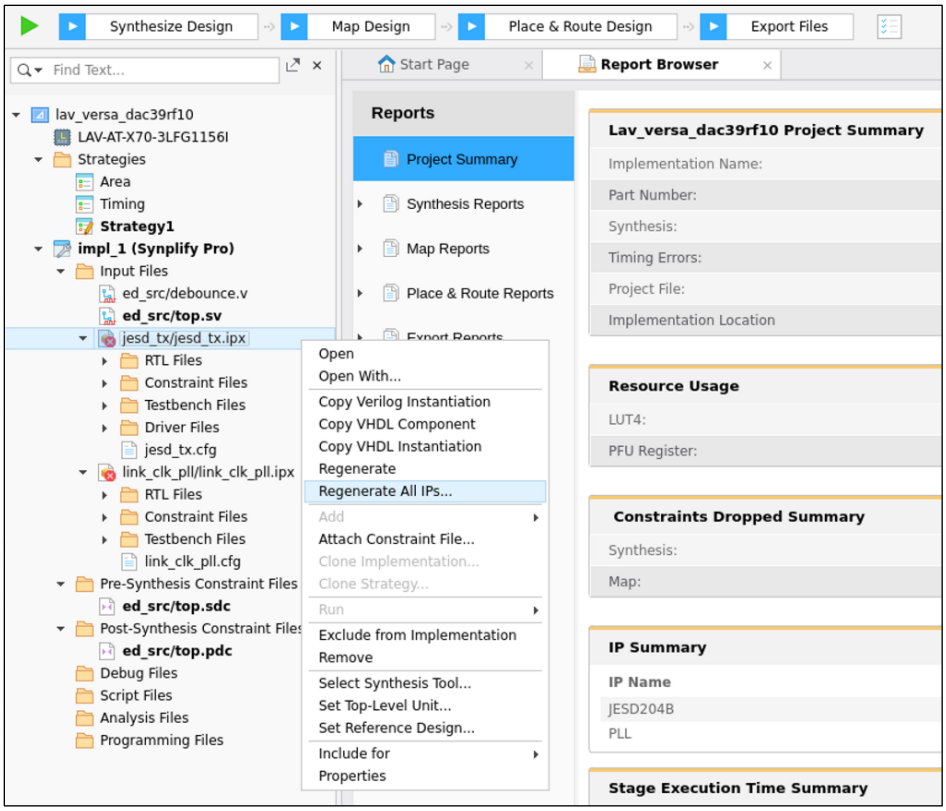


Figure 6.17. Regenerating All IP Instances

6.3.4.3. Hardware Setup

1. Connect the TI DAC39RF10EVM to the Avant-X Versa Board.
2. Make sure that the JP1 jumper on the Avant-X Versa Board is connected with a jumper pin to allow configuring from the JTAG port.
3. Connect a USB cable from your PC to the mini-USB connector on the Avant-X Versa Board.
4. Connect the required 12-V power supply to the DAC39RF10EVM.
5. Connect a mini-USB cable between the DAC39RF10EVM and your PC with the DAC39RF10EVM GUI installed.
6. Connect a 1966.08-MHz clock to the DAC39RF10EVM through the LMX CLKP/N SMA connector port.
7. Connect the OUTAp SMA connector to an external oscilloscope to view the generated waveform.

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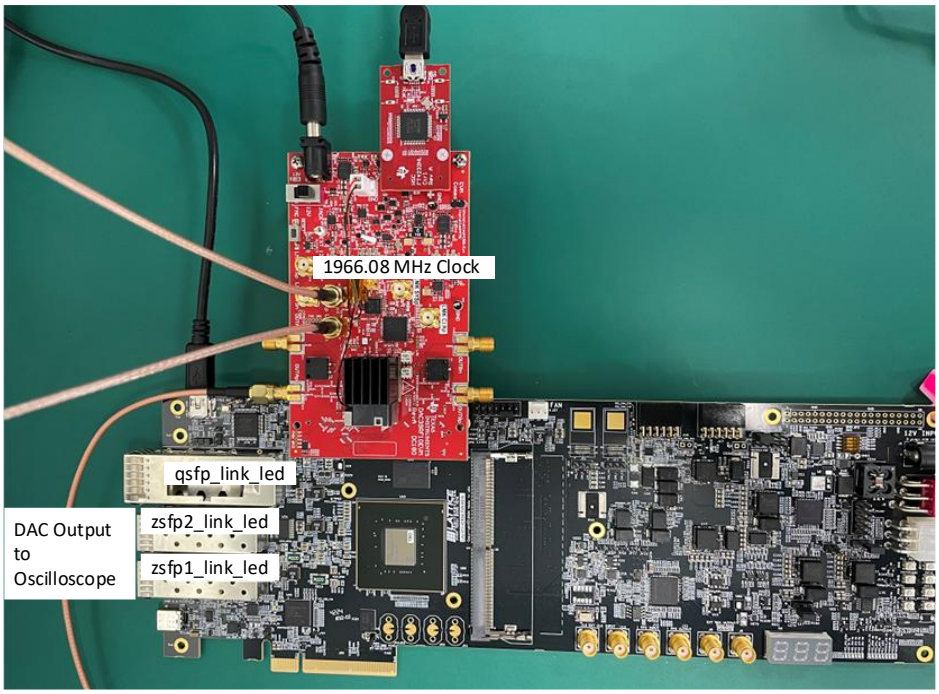


Figure 6.18. Avant Versa Board (Top) with TI DAC39RF10EVM Evaluation Board (Bottom)

6.3.4.4. Running the Design

1. Open the DAC39RF10EVM GUI software. Ensure that the installed version is v3.1.2.
2. In the **Select FTDI Device** window, select the FTDI and board type, then click **Select FTDI and Board Type**.

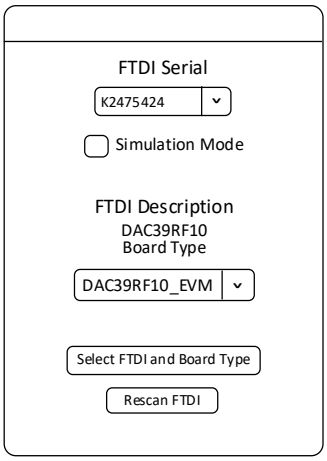


Figure 6.19. DAC39RF10EVM GUI (Select FTDI Device Window)

3. On the **JESD Configuration** tab of the **DAC39RF1xEVM** window, configure the settings to the following values:
   - Update Rate: 1.96608G
   - Real Data: Enabled
   - Channel Count: 2
   - Interpolation: 1
   - DAC Resolution: 16 bit
   - JESD Protocol: 8b10b

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- JESD Subclass: 1
- JESD Format: Two's Comp
- JMODE: 2

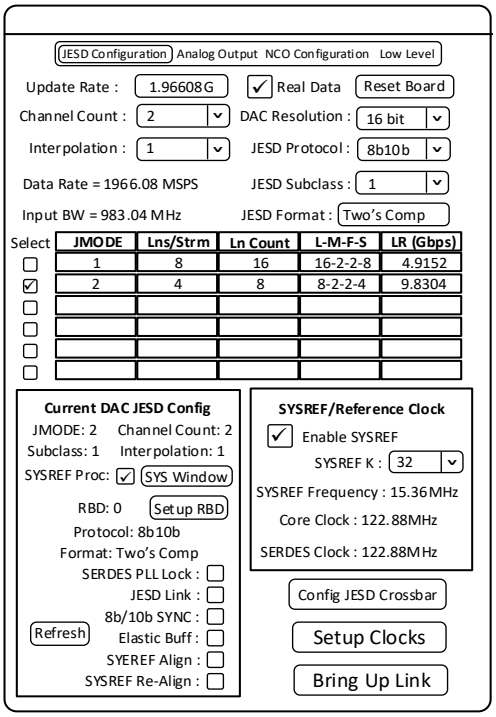


Figure 6.20. DAC39RF10EVM GUI (DAC39RF1xEVM Window)

4. Click **Config JESD Crossbar**. The **JESD Crossbar Configuration** window opens.

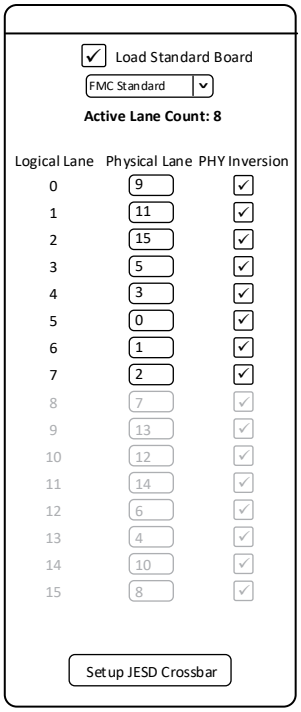


Figure 6.21. JESD Crossbar Configuration Window

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5. Check to enable **Load Standard Board**, then select **FMC Standard** from the drop-down list.
6. Click **Setup JESD Crossbar**.
7. Close the **JESD Crossbar Configuration** window after configuration is done.
8. On the **JESD Configuration** tab, click **Setup Clocks** followed by **Brink Up Link**. The *Current DAC JESD Config* information displayed at the bottom left of the GUI must match the expected values for JMODE, Subclass, Channel Count, Interpolation, Protocol, and Format. **Enable SYSREF** under *SYSREF/Reference Clock* must also be checked. If the values are different from the expected values, repeat Steps 3 to 8.
9. Click **Refresh** under *Current DAC JESD Config*. The *SERDES PLL Lock* status turns green.
10. Open the Radiant Programmer tool.
11. Locate the bitstream generated in the impl_1 folder and program the bitstream to the FPGA. Upon successful programming, three green LEDs on the Avant-X Versa Board light up.

Table 6.6. Summary of LED Indicators on Avant-X Versa Board (Tx Example Design)

LED	Pin	Description
qsfp_link_led	AN10	Tx PHY has gone through calibration and is ready when the LED lights up.
zsfp1_link_led	AJ13	Tx JESD core is in the user data phase when the LED lights up.
zsfp2_link_led	AH13	TREADY signal from JESD Tx core transport layer. The core is ready to accept user data when the LED lights up.

12. In the DAC39RF10EVM GUI software, click **Refresh** under *Current DAC JESD Config* on the **JESD Configuration** tab. When the link is up, you can see the waveform on your oscilloscope.



Figure 6.22. Output Waveform on Oscilloscope

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7. Designing with the IP

This section describes how to generate the IP core using the Lattice Radiant software and how to run simulation and synthesis. For more details on the Lattice Radiant software, refer to the Lattice Radiant Software User Guide.

Note: The screenshots provided are for reference only. Details may vary depending on the version of the IP or software being used. If there have been no significant changes to the GUI, a screenshot may reflect an earlier version of the IP.

7.1. Generating and instantiating the IP

You can use the Lattice Radiant software to generate IP modules and integrate them into the device architecture. The steps below describe how to generate the JESD204B IP in the Lattice Radiant software.

To generate the JESD204B IP:

1. Create a new Lattice Radiant software project or open an existing project.
2. In the **IP Catalog** tab, double-click **JESD204B** under **IP, Connectivity** category. The **Module/IP Block Wizard** opens as shown in Figure 7.1. Enter values in the **Component name** and the **Create in** fields and click **Next**.

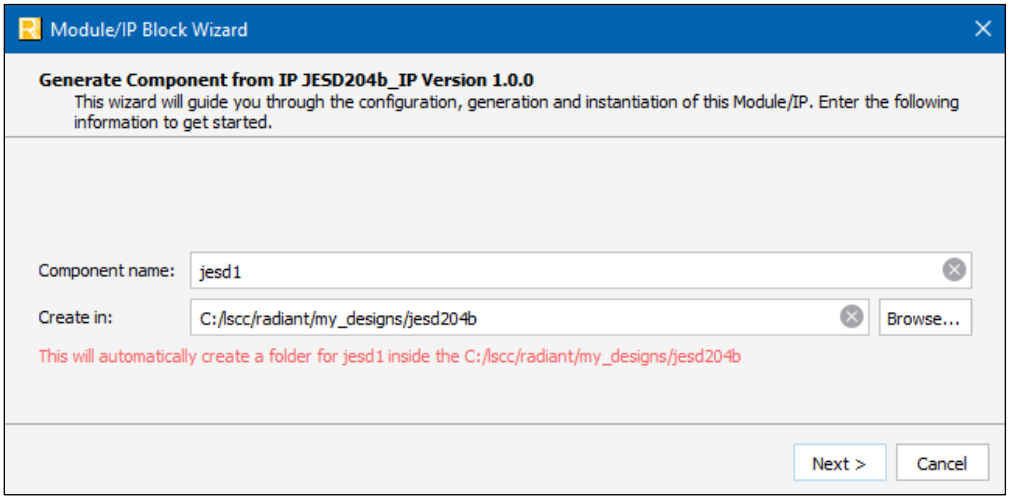


Figure 7.1. Module/IP Block Wizard

3. In the next **Module/IP Block Wizard** window, customize the selected JESD204B IP using drop-down lists and check boxes. Figure 7.2 shows an example configuration of the JESD204B IP. For details on the configuration options, refer to the IP Parameter Description section.

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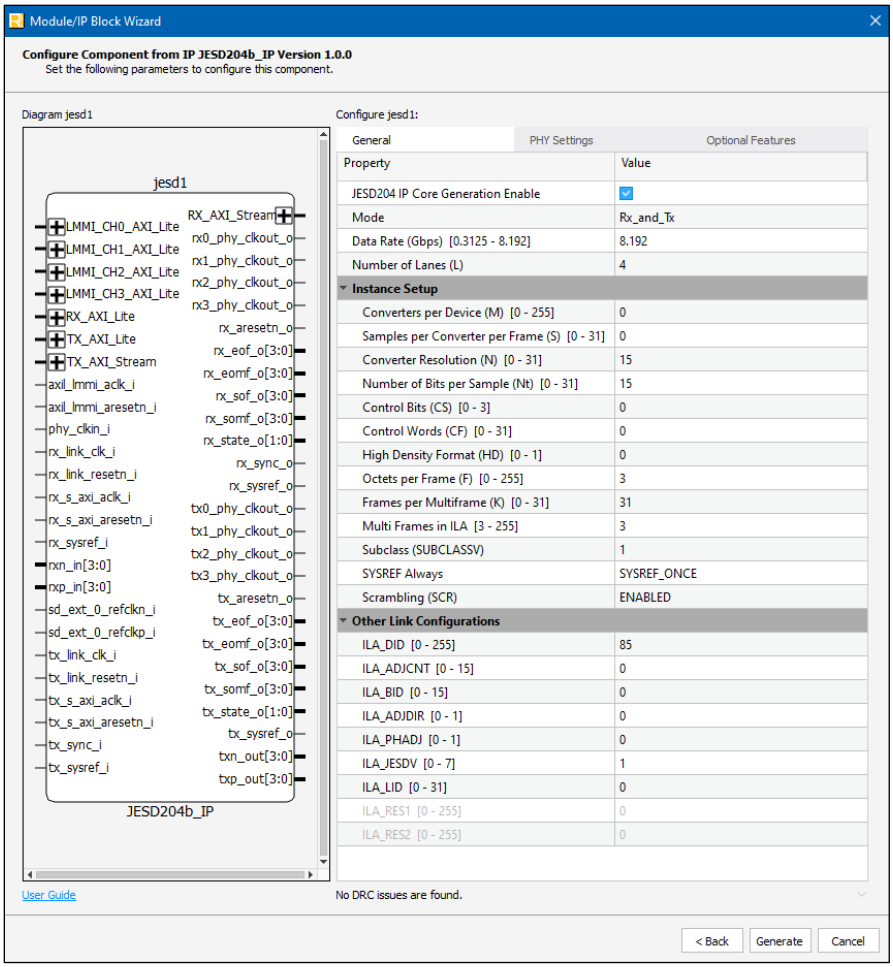


Figure 7.2. IP Configuration

4. Click **Generate**. The **Check Generated Result** dialog box opens, showing design block messages and results as shown in Figure 7.3.

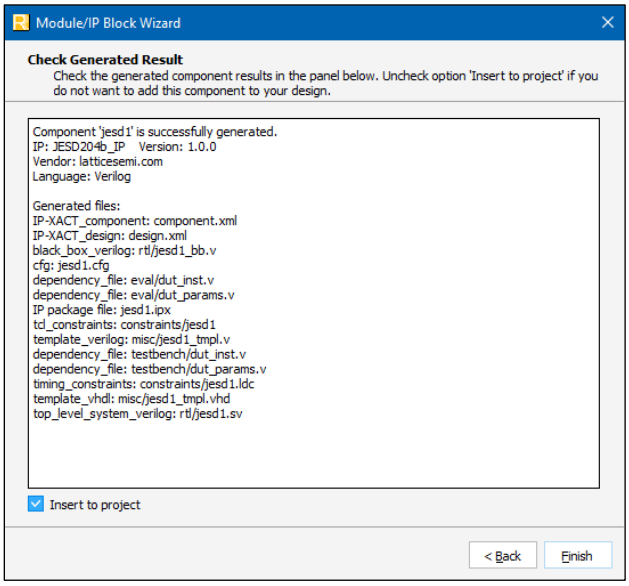


Figure 7.3. Check Generated Result

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5. Click **Finish**. All the generated files are placed under the directory paths in the **Create in** and the **Component name** fields shown in Figure 7.1.

7.1.1. Generated Files and File Structure

The generated JESD204B module package includes the closed-box (<Component name>_bb.v) and instance templates (<Component name>_tmpl.v/vhd) that can be used to instantiate the core in a top-level design. An example RTL top-level reference source file (<Component name>.sv) that can be used as an instantiation template for the module is also provided. You may also use this example as the starting template for your top-level design. The generated files are listed in Table 7.1.

Table 7.1. Generated File List

Attribute	Description
<Component name>.ipx	Contains the information on the files associated to the generated IP.
<Component name>.cfg	Contains the parameter values used in IP configuration.
component.xml	Contains the ipxact: component information of the IP.
design.xml	Documents the configuration parameters of the IP in IP-XACT 2014 format.
rtl/<Component name>.sv	Provides an example RTL top file that instantiates the module.
rtl/<Component name>_bb.v	Provides the synthesis closed-box.
misc/<Component name>_tmpl.v misc /<Component name>_tmpl.vhd	Provide instance templates for the module.

7.2. Design Implementation

Completing your design includes additional steps to specify analog properties, pin assignments, and timing and physical constraints. You can add and edit the constraints using the Device Constraint Editor or by manually creating a .pdc file.

Post-synthesis constraint files (.pdc) contain both timing and non-timing constraint.pdc source files for storing logical timing/physical constraints. Constraints that are added using the Device Constraint Editor are saved to the active .pdc file. The active post-synthesis design constraint file is then used as input for post-synthesis processes.

Refer to the relevant sections in the Lattice Radiant Software User Guide for more information on how to create or edit constraints and how to use the Device Constraint Editor.

7.3. Timing Constraints

For Avant-G, Avant-X, and Certus-N2 devices, the PHY Tx and Rx PMA output clock constraints might not generate correctly. Before running place and route, manually configure the clock constraints in the post-synthesis constraint files (.pdc). Refer to the MPPHY Module User Guide (FPGA-IPUG-02233) for the clock constraint information.

7.4. Specifying the Strategy

The Radiant software provides two predefined strategies: Area and Timing. It also enables you to create customized strategies. For details on how to create a new strategy, refer to the Strategies section of the Lattice Radiant Software User Guide.

For CertusPro-NX devices, if you face timing issues at a high data rate, configure Radiant Strategies: *Place & Route Design: Path-based Placement* to *OFF* and *Pack Logic Block Utility* to a smaller number to improve the place and route performance for this IP.

7.5. Running Functional Simulation

You can run functional simulation after the IP is generated.

To run functional simulation:

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1. Click the button located on the **Toolbar** to initiate the **Simulation Wizard** shown in Figure 7.4.

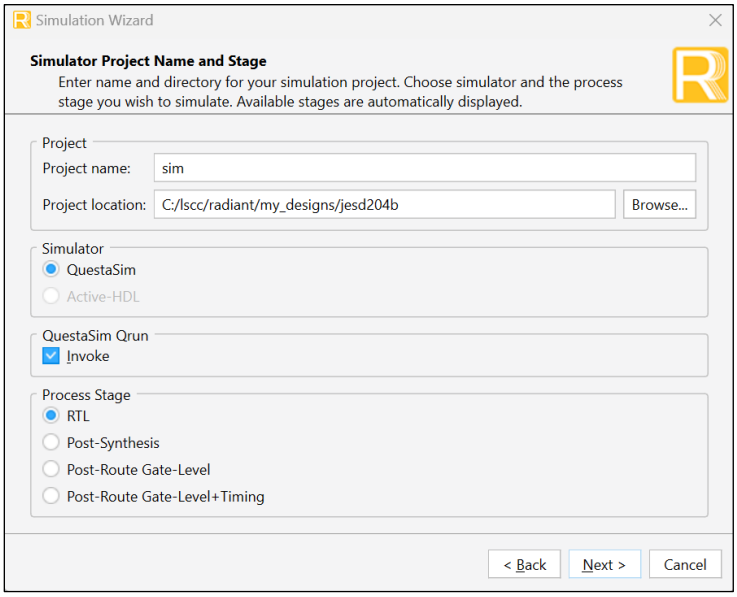


Figure 7.4. Simulation Wizard

2. Click **Next** to open the **Add and Reorder Source** window as shown in Figure 7.5.

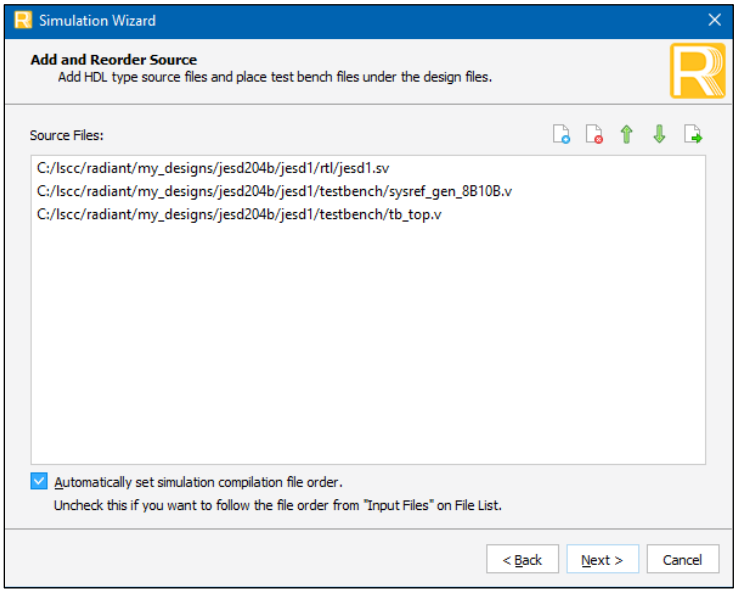


Figure 7.5. Add and Reorder Source

3. Click **Next**. The **Summary** window appears. Change the **Default Run** value to *0* and **Simulator Resolution** to *fs*.
4. Click **Finish** to run the simulation.

The waveform in Figure 7.6 shows an example simulation result.

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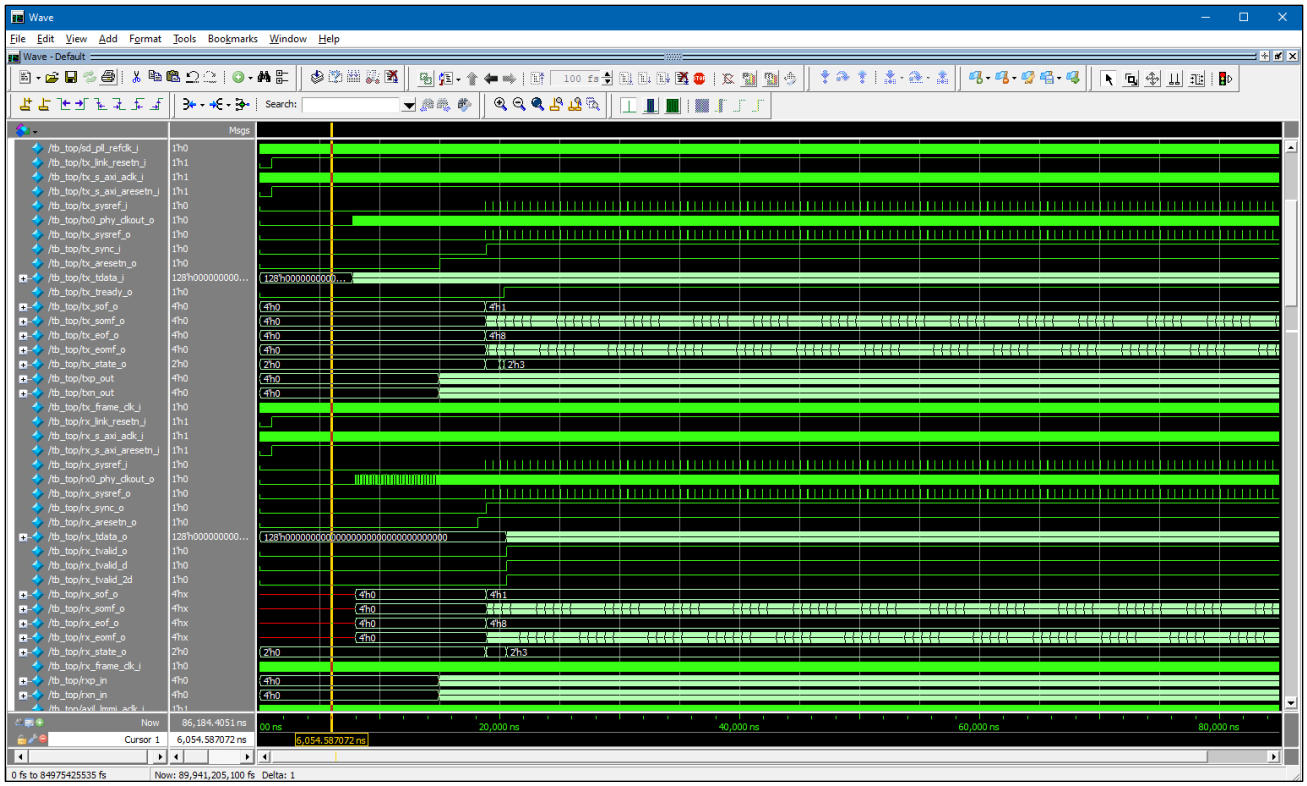


Figure 7.6. Simulation Waveform

7.5.1. Simulation Results

At the end of the test run, the simulation results show whether the simulation passed or failed. Figure 7.7 shows an example simulation result.

```
# ==============Incremental Data================
# 250000 JESD Link-up is done
# Data Passed
# ================================================================
# ************************SIMULATION PASSED************************
# ================================================================
# ** Note: $finish    : C:/lscc/radiant/my_designs/jesd204b/jesd1/testbench/tb_top.v(859)
#    Time: 250 us  Iteration: 0  Region: /tb_top/genblk2
```

Figure 7.7. Test Transcript Result

The simulation waveform /tb_top/error signals show if any data mismatch was detected. Figure 7.8 shows an example passing simulation waveform.

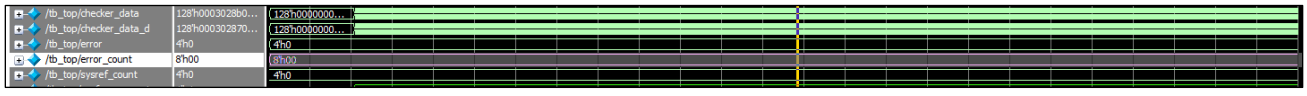


Figure 7.8. Example Passing Simulation Waveform

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Appendix A. Resource Utilization

Note: Resource utilization values in this section are provided for reference only and may change based on the compilation strategy and selected tool options.

Table A.1 and Table A.2 show sample resource utilization of the JESD204B IP core on the LAV-AT-X70 and LFCPNX-100 devices, respectively.

Table A.1. Resource Utilization on LAV-AT-X70 LFG1156 Device

IP Configuration	JESD204B IP	LUT4		PFU Registers	EBR
		Logic	Ripple Logic		
Mode = Rx_and_Tx *Number of Lanes* = 8 *Scrambling* = Enabled Number of *Octets per Frame (F)* = 4 Number of *Frames per Multiframe (K)* = 32 *Transport Layer Enable* = Unchecked	Rx Link Wrapper	4552	560	5937	8
	Tx Link Wrapper	3068	296	3759	0
	Tx and Rx PHY Wrapper	287	32	616	0
Mode = Rx_and_Tx *Number of Lanes* = 8 *Scrambling* = Enabled Number of *Octets per Frame (F)* = 4 Number of *Frames per Multiframe (K)* = 32 *Transport Layer Enable* = Checked	Rx Link Wrapper	4611	572	6481	12
	Tx Link Wrapper	3063	308	4330	4
	Tx and Rx PHY Wrapper	280	32	616	0

Table A.2. Resource Utilization on LFCPNX-100 LFG672 Device

IP Configuration	JESD204B IP	LUT4		PFU Registers	EBR
		Logic	Ripple Logic		
Mode = Rx_and_Tx *Number of Lanes* = 4 *Scrambling* = Enabled Number of *Octets per Frame (F)* = 4 Number of *Frames per Multiframe (K)* = 32 *Transport Layer Enable* = Unchecked	Rx Link Wrapper	2580	474	3863	4
	Tx Link Wrapper	1828	326	2683	0
	Tx and Rx PHY Wrapper	375	40	463	0
Mode = Rx_and_Tx *Number of Lanes* = 4 *Scrambling* = Enabled Number of *Octets per Frame (F)* = 4 Number of *Frames per Multiframe (K)* = 32 *Transport Layer Enable* = Checked	Rx Link Wrapper	2900	488	4547	8
	Tx Link Wrapper	1673	340	2940	4
	Tx and Rx PHY Wrapper	375	40	463	0

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References

- JESD204B IP Release Notes (FPGA-RN-02006)
- JESD204B Driver API Reference (FPGA-TN-02412)
- MPCS Module – Lattice Radiant Software User Guide (FPGA-IPUG-02118)
- CertusPro-NX SerDes/PCS User Guide (FPGA-TN-02245)
- Lattice Avant SERDES/PCS User Guide (FPGA-TN-02313)
- Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395)
- MPPHY Module User Guide (FPGA-IPUG-02233)
- Lattice Radiant Timing Constraints Methodology (FPGA-AN-02059)
- CertusPro-NX web page
- Avant-G web page
- Avant-X web page
- Certus-N2 web page
- CertusPro-NX Evaluation Board web page
- Avant-X Versa Board web page
- ADI ADRV9009 Dual RF Evaluation Board web page
- TI ADC32RF45 web page
- TI ADC32RF45EVM-GUI web page
- TI DAC39RF10EVM Evaluation Board web page
- TI DAC39RF10 web page
- TI DAC39RF10EVM-GUI web page
- JESD204B IP Core web page
- Lattice Radiant Software web page
- Lattice Propel Design Environment web page
- Lattice Solutions IP Cores web page
- Lattice Solutions Reference Designs web page
- Lattice Insights for Lattice Semiconductor training courses and learning plans

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Revision History

Note: In some instances, the IP may be updated without changes to the user guide. The user guide may reflect an earlier IP version but remains fully compatible with the later IP version. Refer to the IP Release Notes for the latest updates.

Revision 1.6, IP v1.5.0, October 2026

Section	Change Summary
All	Made minor editorial changes.
Abbreviations in This Document	Updated definition for *PHY*.
Introduction	In Table 1.1. Summary of the JESD204B IP: • Updated IP core version and software version in *Lattice Implementation*.
Functional Description	Updated Figure 2.1. JESD204B IP Block Diagram and Figure 2.19. AXI4-Lite to LMMI Read Timing Diagram.
IP Parameter Description	In Table 3.2. PHY Attributes: • Added the attributes *LMMI AXI-L Address Width* and *Data Polarity Inversion Enable*.
Designing with the IP	Added the Timing Constraints section.
References	• Added MPPHY Module User Guide (FPGA-IPUG-02233). • Added TI ADC32RF45EVM-GUI web page. • Updated TI DAC39RF10EVM-GUI web page link.

Revision 1.5, IP v1.4.0, June 2026

Section	Change Summary
All	Made minor editorial changes.
Introduction	In Table 1.1. Summary of the JESD204B IP: • Updated IP core version and software version in *Lattice Implementation*.
IP Parameter Description	In the JESD204B Link Layer Only Mode section: • Updated description to indicate that embedded transport layer is optional.
Signal Description	In Table 4.1. Signal Ports: • Corrected cross reference to note in description for rxN_phy_resetn_i. • Corrected description for rx_state_o.

Example Design	• In Table 6.3. JESD204B IP Configuration Supported by the Avant-X Versa Board Rx Example Design:
	  • Corrected *Frame per Clock* to 1.
	• In the RISC-V Software section:
	  • Added folder name in Step 11.
	  • Added example git client software to note in Step 12.
	  • Clarified the location of the new Debug folder in Step 16.
	• In the RTL Design section:
	  • Updated the IP versions for AHB-Lite to AXI4 Bridge, UART, AHB Lite Interconnect, AHB Lite to APB Bridge, and APB Interconnect in Step 6.
	• In the TI ADC32RF44EVM Setup section:
	  • Updated link in Step 3 to TI ADC32RF45 web page.

Design Considerations	Removed section.

Appendix A. Resource Utilization	• Added note on resource utilization values.
	• In Table A.1. Resource Utilization on LAV-AT-X70 LFG1156 Device:
	  • Updated LUT4 logic values across conditions and wrappers.
	  • Updated LUT4 ripple logic and PFU register values for Rx link wrapper with *Transport Layer Enable* = Unchecked and *Transport Layer Enable* = Checked.
	• In Table A.2. Resource Utilization on LFCPNX-100 LFG672 Device:
	  • Updated LUT4 logic and PFU register values for Rx link wrapper with *Transport Layer Enable* = Unchecked and for Tx link wrapper with *Transport Layer Enable* = Checked.

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Section	Change Summary
References	• Removed link to TI ADC32RF45EVM Evaluation Board web page. • Added TI ADC32RF45 web page.

Revision 1.4, IP v1.3.0, April 2026

Section	Change Summary
All	Made minor editorial changes.

Introduction	• In the IP Support Summary section:
	  • In Table 1.2. JESD204B IP Support Readiness:
	  • Removed the *Hardware Validated* column.
	  • Added statement on example design and cross reference to the Example Design section.
	• Removed the Hardware Support section.

Design Considerations	Added new section.

Revision 1.3, IP v1.3.0, December 2025

Section	Change Summary
All	• Added a note on the IP version in the Quick Facts and Revision History sections. • Made minor editorial changes.
Abbreviations in This Document	Added *FMC* and *FTDI*.

Introduction	• In Table 1.1. Summary of the JESD204B IP:
	  • Added Certus-N2 to *Supported Devices*.
	  • Updated IP core version and software version in *Lattice Implementation*. Also, added *Lattice Propel Design Environment*.
	  • Added *Driver Support* row.
	• In Table 1.2. JESD204B IP Support Readiness:
	  • Added Certus-N2.
	• In the Features section:
	  • Added Certus-N2 to listings for lane rates and configurable lane counts.
	• In Table 1.3. Ordering Part Number:
	  • Added Certus-N2.
	• In Table 1.4. Minimum Device Requirements for JESD204B IP:
	  • Updated link speed for Avant-G and Avant-X speed grade 1.
	  • Added Certus-N2.

Functional Description	In the AXI4-Lite to LMMIAXI4-Lite to LMMI section: • Added reference to Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395).

IP Parameter Description	• In Table 3.1. General Attributes:
	  • Updated data rate range for CertusPro-NX device.
	  • Updated data rate selection information for Avant-G/X device and added note on valid ranges.
	  • Added Certus-N2 to *Data Rate* attribute.
	  • Updated note on Avant-G/X device data rate support to indicate multiple continuous ranges. Also, added Certus-N2 to note.
	• In Table 3.2. PHY Attributes:
	  • Added Certus-N2 to *Lane ID* and *Ref Clk Freq* attributes.
	  • Updated reference clock frequency example values for CertusPro-NX device at < 2.97 Gb/s.
	  • Updated reference clock frequency selection information for Avant-G/X device.

Signal Description	• In Table 4.1. Signal Ports: • Under JESD Rx Embedded Transport Layer Interface [Clock domain = tx_frame_clk_i] section, updated description of tx_frame_clk_i to include reference to the Clock

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Section	Change Summary

	Interface section.
	• Under JESD Tx AXI4 Lite Register Interface section, updated and added frequency range to description of tx_s_axi_aclk_i.
	• Under JESD Rx Embedded Transport Layer Interface [Clock domain = rx_frame_clk_i] section, updated description of rx_frame_clk_i to include reference to the Clock Interface section.
	• Under JESD Rx AXI4 Lite Register Interface section, updated and added frequency range to description of rx_s_axi_aclk_i.
	• Under AXI-Lite to PHY LMMI Interface section:
	  • Added clock source information for CertusPro-NX, Avant-G/X, and Certus-N2 devices to description of axil_lmmi_aclk_i.
	  • Added reference to Certus-N2 and Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395) to description for axil_lmmi_awvalid_N_i through axil_lmmi_rresp_N_o.
	• Added Certus-N2 to Note 1.
	• In Table 4.2. Clock Ports:
	• Updated section name to *PHY Layer for Avant-G/X and Certus-N2*.
	• Under PHY Layer for Avant-G/X and Certus-N2 section, updated reference clock frequency information in description of refclk_p_i.
	• Under PHY Layer across All Devices section, added clock source information for CertusPro-NX, Avant-G/X, and Certus-N2 devices to description of axil_lmmi_aclk_i.
	• Under Link and Transport Layer section
	  • Added frequency range to descriptions of tx_s_axi_aclk_i and rx_s_axi_aclk_i.
	  • Added note on maximum supported frequency for CertusPro-NX devices to descriptions of tx_frame_clk_i and rx_frame_clk_i.

Register Description	• In Table 5.14. Rx Register Map Overview: • Added Buffer Fill Level Register. • In Table 5.17. Rx Error Status Register: • Updated description of Unexpected Control Character Flag to include behavior when operating in Subclass 0 mode. • In Table 5.26. Rx Error Counter Register: • Updated description of Unexpected Control Character Flag to include behavior when operating in Subclass 0 mode. • Added the Buffer Fill Level Register section.

Example Design	• In the CertusPro-NX Device Example Design section:
	• Removed note on check and cross symbols in the Example Design Supported Configuration section.
	• In Table 6.1. JESD204B IP Configuration Supported by the CertusPro-NX Device Example Design:
	  • Replaced check symbol with *Checked* and cross symbol with *Unchecked* where applicable. Replaced cross symbol with em-dash if not applicable.
	• In the Running the Hardware without Rebuilding the Design section:
	  • Updated description in Step 8 to emphasize setting the serial line and baud rate before programming when using PuTTY to view log messages.
	  • Updated Figure 6.4. Programming Log Messages and Figure 6.5. CertusPro-NX Evaluation Board (Left) with ADI ADRV9009 Dual RF Evaluation Board (Right).
	• In the Rebuilding the Design section under RISC V Software:
	  • Updated file unzipping instructions in Step 1.
	  • Updated Step 5 to include instructions on handling the *Cannot Connect to the Device* error message.
	  • Updated Step 8 to include reference to Figure 6.7 for JESD204B setup information.
	  • Added Figure 6.7. JESD204B Setup Information.
	  • Updated Step 12 to include note on installing the git client software.

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Section	Change Summary

	• In the Rebuilding the Design section under RTL Design:
	  • Updated Step 4 to include instructions for when a newer version of the system memory module is available.
	  • In Step 6, updated IP versions (AHB-Lite to AXI4 Bridge, GPIO, SPI Controller, AHB Lite Interconnect, and APB Interconnect) and added statement on IP version matching in regen_ip_files.tcl.
	  • Updated Figure 6.12. Regenerating the SoC Design RTL.
	• In the Avant-X Versa Board Rx Example Design section:
	  • Removed note on check and cross symbols in the Example Design Supported Configuration section.
	  • In Table 6.3. JESD204B IP Configuration Supported by the Avant-X Versa Board Rx Example Design:
	  • Replaced check symbol with *Checked* and cross symbol with *Unchecked*.
	  • Updated settings for Converter Resolution, Number of Bits per Sample, Subclass (SUBCLASSV), and SYSREF Always.
	  • In the Generating Bitstream section:
	  • Updated file unzipping instructions in Step 1.
	  • In the TI ADC32RF44EVM Setup section:
	  • Updated Step 3 to reference mini-USB cable.
	  • Removed Step on unzipping the lav_versa_adc32rf44_8l_9p8g.zip file.
	  • Updated Step 4b to specifically mention clock names.
	  • Updated Step 4c to include additional instructions on configuring the ADC32RFxx_DIGITAL block and corrected reference to JESD_DIG_CHB_0x03.
	  • In the Avant-X Versa Board Setup section:
	  • Updated Steps 4 and 5 on locating the generated bitstream file, programming the FPGA, starting the ramp checker with SW13 pushbutton, and master reset through SW12 pushbutton.
	• In the Avant-X Versa Board Tx Example Design section:
	  • Removed note on check and cross symbols in the Example Design Supported Configuration section under .
	  • In Table 6.5. JESD204B IP Configuration Supported by the Avant-X Versa Board Tx Example Design:
	  • Replaced check symbol with *Checked* and cross symbol with *Unchecked*.
	  • In the Pre-requisites section:
	  • Updated version number for TI DAC39RF10EVM-GUI.
	  • Updated clock generator frequency.
	  • In the Generating Bitstream section:
	  • Updated file unzipping instructions in Step 1.
	  • Updated Step 4 to cover regenerating all IP instances.
	  • Updated Figure 6.17. Regenerating All IP Instances and title.
	  • In the Hardware Setup section:
	  • Updated Step 5 to reference mini-USB cable.
	  • In the Running the Design section:
	  • Updated the procedure for DAC39RF10EVM GUI software v3.1.2.
	  • Updated Figure 6.19. DAC39RF10EVM GUI (Select FTDI Device Window) and title.
	  • Added Figure 6.20. DAC39RF10EVM GUI (DAC39RF1xEVM Window) and Figure 6.21. JESD Crossbar Configuration Window.
	  • Updated Figure 6.22. Output Waveform on Oscilloscope.

Designing with the IP	Added note on IP version in GUI.
References	• Added Lattice Nexus 2 SERDES/PCS User Guide (FPGA-TN-02395). • Added Certus-N2 web page.
Appendix A. Resource Utilization	In Table A.1. Resource Utilization on LAV-AT-X70 LFG1156 Device and Table A.2. Resource

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Section	Change Summary
	Utilization on LFCPNX-100 LFG672 Device: • Reformatted LUT4 headers. • Updated LUT4 logic, LUT4 ripple logic, PFU register, and EBR values for various conditions and wrappers. • Removed Rx and Tx transport wrappers.

Revision 1.2, IP v1.2.0, June 2025

Section	Change Summary
Abbreviations in This Document	Added *CMOS*, *FPGA*, *GUI*, *IQ*, *RBD*, *Rx*, *SERDES*, and *Tx*.

Introduction	• In Table 1.1. Summary of the JESD204B IP:
	  • Renamed *Supported FPGA Family* to *Supported Devices* and incorporated *Targeted Devices* information into row.
	  • Removed *Targeted Devices* row.
	  • Added IP core version to *Lattice Implementation*.
	• Removed note to Table 1.2. JESD204B IP Support Readiness regarding preliminary hardware validation setup.
	• In Table 1.3. Ordering Part Number:
	  • Updated header name from *Multi-Site Perpetual* to *Single Seat Perpetual*.
	• In Table 1.4. Minimum Device Requirements for JESD204B IP:
	  • Removed *Link Width* column.

Functional Description	In the Embedded Transport Layer section: • Removed description of link configuration parameters from the JESD204B specification. • Removed the JESD204B Transport Layer Parameter table. • Added notes to Figure 2.9. User Data Format for Independent Lane with Oversampling.

IP Parameter Description	• In Table 3.1. General Attributes:
	  • Added note to *Frames per Multiframe* attribute regarding requirement for (Octets per Frame + 1) x (Frames per Multiframe + 1) to be a multiple of 4.
	  • Made minor editorial change to listing of selectable values for *Data Rate*.
	• In Table 3.2. PHY Attributes:
	  • Made minor editorial change to listing of selectable values for *Lane ID*.

Register Description	• In Table 5.9. Tx Link Config 3 Register:
	  • Added note to Octets per Multiframe register regarding requirement for register value + 1 to be a multiple of 4.
	• In Table 5.21. Rx Link Config 3 Register:
	  • Added note to Octets per Multiframe register regarding requirement for register value + 1 to be a multiple of 4.

Example Design	• Updated description.
	• Added Avant-X Versa Board to list of evaluation boards and updated listing name for CertusPro-NX Evaluation Board.
	• Removed the Simulating the Example Design section.
	• In Table 6.1. JESD204B IP Configuration Supported by the CertusPro-NX Device Example Design:
	  • Updated title.
	  • Removed FIFO Depth in Tx attribute.
	• Updated Figure 6.1. JESD204B Example Design Block Diagram.
	• In the RTL Design section under CertusPro-NX Device Example Design:
	  • Updated Step 6 through Step 10.
	  • Removed the Regenerating IP Instances figure.
	• Added the Avant-X Versa Board Rx Example Design and Avant-X Versa Board Tx Example Design sections.

Designing with the IP	Updated Figure 7.4. Simulation Wizard.

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Section	Change Summary
References	• Added JESD204B Driver API Reference. • Updated listing name to Lattice Radiant Software web page. • Added Avant-X Versa Board, TI ADC32RF45EVM Evaluation Board, TI DAC39RF10EVM Evaluation Board, TI DAC39RF10, TI DAC39RF10EVM-GUI, and JESD204B IP Core web pages.

Revision 1.1, IP v1.1.0, March 2025

Section	Change Summary
All	Made changes to conform with inclusive language guidelines.
Cover	Added IP version.
Abbreviations in This Document	• Updated section title, description, and table header. • Added *DUT* and *ES*.

Introduction	• In Table 1.1. Summary of the JESD204B IP:
	  • Added Lattice Avant to Supported FPGA Family.
	  • Added IP Changes row.
	  • Removed IP Version row.
	  • Added Avant-G and Avant-X to Targeted Devices.
	  • Added IP core version to Lattice Implementation.
	  • Added note on ES devices.
	• Added the IP Support Summary section.
	• In the Features section:
	  • Added lane rate for Avant-X and -G devices and clarified lane rate for CertusPro-NX devices.
	  • Added lane counts for Avant-X and -G devices and clarified lane counts for CertusPro-NX devices.
	• In Table 1.3. Ordering Part Number:
	  • Added part numbers for Avant-G and Avant-X.
	• Removed the IP Validation Summary section.
	• Added the Hardware Support section.
	• In Table 1.4. Minimum Device Requirements for JESD204B IP:
	  • Added Device Family column.
	  • Added link speeds for Avant-G and Avant-X devices.
	  • Updated link speeds for CertusPro-NX device speed grades 7 and 8 (high performance).

Functional Description	• Updated Figure 2.1. JESD204B IP Block Diagram.
	• Updated description in the ILA Detection section.
	• Removed the Link Layer Data Interface Timing Diagram section under the Rx Link Layer section.
	• Removed the Link Layer Data Interface Timing Diagram section under the Tx Link Layer section.
	• Updated Figure 2.14. Timing Diagram with OCTET_PER_FRAME = 3 and TL_FRAME_PER_CLK = 2.
	• Updated Figure 2.15. JESD204B PHY Layer Module.
	• In the PLL Reference Clock for CertusPro-NX Device section:
	  • Updated section title.
	  • Updated description on number of reference clock selections.
	• Updated description and added reference to Lattice Avant SerDes/PCS User Guide in the AXI4-Lite to LMMI section.
	• Updated Figure 2.20. JESD204B IP Clock Domain Block Diagram.
	• In Table 2.5. JESD204B IP Reset Output Overview:
	  • Updated descriptions for tx_aresetn_o and rx_aresetn_o.

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Section	Change Summary

IP Parameter Description	• In Table 3.1. General Attributes:
	  • Added selectable values for data rate for Avant-G/X devices and updated description.
	  • Added supported number of lanes of 8 and updated description.
	  • Added note on Avant-G/X data rate selectable values.
	• In Table 3.2. PHY Attributes:
	  • Added Lane ID values for Avant devices, updated Lane ID values for CertusPro-NX device, and updated Lane ID description.
	  • Updated PMA Reference Clock description.
	  • Updated Ref Clk Freq description.
	  • Updated PLL M Setting description.
	• In Table 3.3. Transport Layer Setup Attributes:
	  • Removed attributes FIFO Depth in Tx and FIFO Depth in Rx.

Signal Description	• Updated Figure 4.1. JESD204B IP Port Interface Overview.
	• In Table 4.1. Signal Ports:
	  • Updated descriptions for tx_link_clk_i, tx_sysref_i, tx_aresetn_o, tx_frame_clk_i, tx_tl_in_tdata_i, txN_phy_usr_clk_o, txN_phy_clkout_o, txN_phy_usr_clk_i, txN_phy_resetn_i, rx_link_clk_i, rx_sysref_i, rx_sysref_o, rx_aresetn_o, rx_frame_clk_i, rxN_phy_usr_clk_o, rxN_phy_clkout_o, rxN_phy_resetn_i, rxN_phy_usr_clk_i, axil_lmmi_aresetn_i, axil_lmmi_aclk_i, and axil_lmmi_awvalid_N_i through axil_lmmi_rresp_N_o.
	  • Updated sections to *JESD Tx PHY to or from Link Bus Interface* and *JESD Rx Link to or from PHY Bus Interface*.
	  • Updated note regarding N in port names.
	• In Table 4.2. Clock Ports:
	  • Updated section to *PHY Layer for CertusPro-NX*.
	  • Updated descriptions for sd_ext_0_refclkp_i, sd_ext_0_refclkn_i, sd_ext_1_refclkp_i, sd_ext_1_refclkn_i, sdq_refclkp_q0_i, sdq_refclkn_q0_i, sdq_refclkp_q1_i, sdq_refclkn_q1_i, pll_0_refclk_i, and pll_1_refclk_i.
	  • Added *PHY Layer for Avant-G/X* section.
	  • Added *PHY Layer across All Devices* section, updated descriptions for axil_lmmi_aclk_i, txN_phy_clkout_o, txN_phy_usr_clk_i, rxN_phy_clkout_o, and rxN_phy_usr_clk_i under section, and regrouped signals under section.
	  • Updated descriptions for tx_s_axi_aclk_i, rx_s_axi_aclk_i, txN_phy_usr_clk_o, and rxN_phy_usr_clk_o.
	  • Updated note on REFCLK frequency.

Register Description	• In Table 5.3. Tx Control Register:
	  • Updated fields to [31:29] for Reserved and [28:16] for LMFC Buffer Adjust.
	  • Updated default value for SYSREF Always Enable.
	• In Table 5.6. Tx Link Config 0 Register:
	  • Updated default values for ILA_SCR, ILA_L, ILA_ADJDIR, ILA_PHADJ, ILA_ADJCNT, ILA_BID, and ILA_DID.
	  • Updated description for ILA_L.
	• In Table 5.7. Tx Link Config 1 Register:
	  • Updated default values for ILA_CS, ILA_N, ILA_M, ILA_K, and ILA_F.
	• In Table 5.8. Tx Link Config 2 Register:
	  • Updated default values for ILA_HD, ILA_CF, ILA_JESDV, ILA_S, ILA_SUBCLASSV, and ILA_Nt.
	• In Table 5.9. Tx Link Config 3 Register:
	  • Updated default values for Multiframes in ILA Sequence and Octets per Multiframe.
	• In Table 5.10. Tx Link Config 4 Register:
	  • Updated default values for ILA_LID_L3, ILA_LID_L2, ILA_LID_L1, and ILA_LID_L0.
	• In Table 5.11. Tx Link Config 5 Register:

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Section	Change Summary
	• Updated field to [31:29] for Reserved. • Added ILA_LID_L7, [23:21] Reserved, ILA_LID_L6, [15:13] Reserved, ILA_LID_L5, [7:5] Reserved, and ILA_LID_L4. • In Table 5.13. Tx Link Config 7 Register: • Added ILA_FCHK_L7, ILA_FCHK_L6, ILA_FCHK_L5, and ILA_FCHK_L4. • In Table 5.15. Rx Control Register: • Updated fields to [31:29] for Reserved and [28:16] for LMDC Buffer Adjust. • Updated description for LMFC Buffer Adjust. • Updated default value for SYSREF Always Enable. • In Table 5.18. Rx Link Config 0 Register: • Updated default values for ILA_SCR, ILA_L, ILA_ADJDIR, ILA_PHADJ, ILA_ADJCNT, ILA_BID, and ILA_DID. • Updated description for ILA_L. • In Table 5.19. Rx Link Config 1 Register: • Updated default values for ILA_CS, ILA_N, ILA_M, ILA_K, and ILA_F. • In Table 5.20. Rx Link Config 2 Register: • Updated default values for ILA_HD, ILA_CF, ILA_JESDV, ILA_S, ILA_SUBCLASSV, and ILA_Nt. • In Table 5.21. Rx Link Config 3 Register: • Updated default values for Multiframes in ILA Sequence and Octets Per MultiFrame. • In Table 5.22. Rx Link Config 4 Register: • Updated default values for ILA_LID_L3, ILA_LID_L2, ILA_LID_L1, and ILA_LID_L0. • In Table 5.23. Rx Link Config 5 Register: • Updated field to [31:29] for Reserved. • Added ILA_LID_L7, [23:21] Reserved, ILA_LID_L6, [15:13] Reserved, ILA_LID_L5, [7:5] Reserved, and ILA_LID_L4. • In Table 5.25. Rx Link Config 7 Register: • Added ILA_FCHK_L7, ILA_FCHK_L6, ILA_FCHK_L5, and ILA_FCHK_L4.
Example Design	• Added introductory paragraph to list the evaluation boards used for the example design. • Rearranged the Simulating the Example Design section to under the Example Design section and updated description. • Updated description in the Example Design Test Bench section. • Reorganized content into the CertusPro-NX Device Example Design section. • Updated description in the JESD204B PHY section. • In Table 6.2. Summary of LED Indicators on CPNX Evaluation Board: • Updated descriptions of green LEDs LED_0 through LED_6. • Updated descriptions of yellow LEDs LED_8, LED_9, LED_14, and LED_15. • Removed the following figures: • ADRV9008/ADRV9009 Evaluation Software GUI • Loading GUI Setup • Setup Loaded Successfully • Creating Script
Designing with the IP	• Removed the Timing Constraints section. • Updated description in the Specifying the Strategy section. • Updated Step 3 in the Running Functional Simulation section. • Updated Figure 7.8. Example Passing Simulation Waveform title and added introducing sentence.
Appendix A. Resource Utilization	• Added Table A.1. Resource Utilization on LAV-AT-X70 LFG1156 Device. • Updated LUT4 Logic, LUT4 Ripple Logic, PFU Registers, and EBR values in Table A.2. Resource Utilization on LFCPNX-100 LFG672 Device.
References	• Rearranged items. • Added Lattice Avant SERDES/PCS User Guide.

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Section	Change Summary
	• Added Avant-X and Avant-G web pages. • Removed Lattice Radiant Software User Guide. • Added CertusPro-NX Evaluation Board, ADI ADRV9009 Dual RF Evaluation Board, and Lattice Solutions Reference Designs web pages.

Revision 1.0, June 2024

Section	Change Summary
All	Initial release.

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