Virtex UltraScale FPGA VCU1287 Characterization Kit IBERT

Getting Started Guide

Vivado Design Suite

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Revision History

The following table shows the revision history for this document.

Date	Version	Revision
12/20/2017	2017.4	Updated for Vivado Design Suite 2017.4. Design file changed to `rdf0368-vcu1287-ibert-2017-4.zip`.
10/09/2017	2017.3	Updated for Vivado Design Suite 2017.3. Design file changed to `rdf0368-vcu1287-ibert-2017-3.zip`.
06/20/2017	2017.2	Updated for Vivado Design Suite 2017.2. Design file changed to `rdf0368-vcu1287-ibert-2017-2.zip`.
04/19/2017	2017.1	Updated graphics and text for Vivado Design Suite 2017.1. Design file changed to `rdf0368-vcu1287-ibert-2017-1.zip`.
12/15/2016	2016.4	Updated for Vivado Design Suite 2016.4. Design file changed to `rdf0368-vcu1287-ibert-2016-4.zip`.
10/12/2016	2016.3	Updated for Vivado Design Suite 2016.3. Design file changed to `rdf0368-vcu1287-ibert-2016-3.zip`. Updated Figure 1-14, Figure 1-22, Figure 2-1, Figure 2-4, Figure 2-9, Figure 2-15, and Figure 2-20.
06/08/2016	2016.2	Updated for Vivado Design Suite 2016.2. Design file changed to `rdf0368-vcu1287-ibert-2016-2.zip`.
04/13/2016	2016.1	Updated for Vivado Design Suite 2016.1. Design file `rdf0368-vcu1287-ibert-2015-4.zip` changed to `rdf0368-vcu1287-ibert-2016-1.zip`. Updated Figure 1-19 and Figure 1-23. Added Training Resources in Appendix B.
02/22/2016	1.0	Initial Xilinx release.

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VCU1287 IBERT Getting Started Guide

Overview

This document describes setting up the Virtex® UltraScale™ FPGA VCU1287 GTH and GTY Transceiver Characterization Board and running the Integrated Bit Error Ratio Test (IBERT) demonstration using the Vivado® Design Suite. The designs required to run the IBERT demonstration are stored in a Secure Digital (SD) memory card that is provided with the VCU1287 board. The demonstration shows the capabilities of the Virtex UltraScale XCVU095-FFVB2104 FPGA GTH and GTY transceiver.

The VCU1287 board is described in detail in the *VCU1287 Characterization Board User Guide* (UG1121) [Ref 1].

The IBERT demonstrations in this guide operate one GTH Quad and one GTY Quad. The procedure consists of:

1. Setting Up the VCU1287 Board

2. Extracting the Project Files

3. Connecting the GTH Transceivers and Reference Clocks

4. Starting the SuperClock-2 Module

5. Configuring the FPGA

6. Setting Up the Vivado Design Suite for the GTH IBERT Demonstration

7. Viewing GTH Transceiver Operation

8. Closing the IBERT Demonstration

9. Connecting the GTY Transceivers and Reference Clocks

10. Starting the SuperClock-2 Module

11. Configuring the FPGA

12. Setting Up the Vivado Design Suite for the GTY IBERT Demonstration

13. Viewing GTY Transceiver Operation

14. Closing the IBERT Demonstration

Requirements

The following hardware and software are required to run and rebuild the IBERT demonstration designs:

- Virtex UltraScale FPGA VCU1287 GTH and GTY transceiver characterization board kit, which includes:
  - Virtex UltraScale FPGA VCU1287characterization board
  - One SD card containing the IBERT demonstration designs
  - One Samtec Bulls Eye® cable
  - Eight SMA female-to-female (F-F) adapters
  - Six 50Ω SMA terminators
  - UltraScale transceiver power supply module (installed onboard)
  - SuperClock-2 module, Rev 1.0 (installed onboard)
  - Active BGA heat sink (installed on FPGA)
  - 12V DC power adapter
  - Two USB cables, standard-A plug to micro-B plug
- Host PC with:
  - SD card reader
  - USB ports
  - a version of Windows supported by the Xilinx Vivado Design Suite
- Xilinx Vivado Design Suite 2017.4

The hardware and software required to rebuild the IBERT demonstration designs are:

- Xilinx Vivado Design Suite 2017.4
- PC with a Windows version supported by the Xilinx Vivado Design Suite

Setting Up the VCU1287 Board

This section describes how to set up the VCU1287 board.

CAUTION! The VCU1287 board can be damaged by electrostatic discharge (ESD). Follow standard ESD prevention measures when handling the board, such as using a grounding strap and static dissipative mat.

When shipped, the VCU1287 board is configured to support both GTH and GTY IBERT demonstrations described in this document. If the board has been re-configured, it must be returned to the default setup before running the IBERT demonstrations. To return it to the default setup, follow these steps:

1. Move all jumpers and switches to their default positions. The default jumper and switch positions are listed in the *VCU1287 Characterization Board User Guide* (UG1121) [Ref 1].

2. Confirm that the UltraScale transceiver power modules are plugged into connectors J124–J46 and J138.

3. Confirm that the SuperClock-2 module is installed. See *HW-CLK-101-SCLK2 SuperClock-2 Module User Guide* (UG770) [Ref 2].

   a. Align the three metal standoffs on the bottom side of the module with the three mounting holes in the SUPERCLOCK-2 MODULE interface of the VCU1287 board.

   b. Using three 4-40 x 0.25 inch screws, firmly screw down the module from the bottom of the VCU1287 board.

   c. On the SuperClock-2 module, place a jumper across pins 2–3 (2V5) of the CONTROL VOLTAGE header, J18, and place another jumper across Si570 INH header J11.

   d. Screw down a 50Ω SMA terminator onto each of the six unused Si5368 clock output SMA connectors: J7, J8, J12, J15, J16, and J17.

Extracting the Project Files

The Vivado Design Suite BIT files required to run the IBERT demonstrations are located in `rdf0368-vcu1287-ibert-2017-4.zip` on the SD card provided with the VCU1287 board. The BIT files are also available online at Virtex UltraScale FPGA VCU1287 Characterization Kit documentation.

The ZIP file contains these BIT files:

- vcu1287_ibert_q124_125.bit
- vcu1287_ibert_q125_125.bit
- vcu1287_ibert_q126_125.bit
- vcu1287_ibert_q127_125.bit
- vcu1287_ibert_q128_125.bit
- vcu1287_ibert_q129_125.bit
- vcu1287_ibert_q130_125.bit
- vcu1287_ibert_q131_125.bit
- vcu1287_ibert_q224_125.bit
- vcu1287_ibert_q225_125.bit
- vcu1287_ibert_q226_125.bit
- vcu1287_ibert_q227_125.bit
- vcu1287_ibert_q228_125.bit
- vcu1287_ibert_q229_125.bit
- vcu1287_ibert_q230_125.bit
- vcu1287_ibert_q231_125.bit

To copy the files from the SD card:

1. Connect the SD card to the host computer.
2. Locate the file `rdf0368-vcu1287-ibert-2017-4.zip` on the SD card.
3. Unzip the files to a working directory on the host computer.

# Running the GTH IBERT Demonstration

The GTH IBERT demonstration operates one GTH Quad at a time. This section describes how to test GTH Quad 224. The remaining GTH Quads can be tested by following a similar series of steps.

Connecting the GTH Transceivers and Reference Clocks

Figure 1-1 shows the locations for GTH and GTY transceiver Quads on the VCU1287 board.

Note: Quads 133, 232, and 233 are not available on the XCVU095 device.

Note: Figure 1-1 is for reference only and might not reflect the current revision of the board.
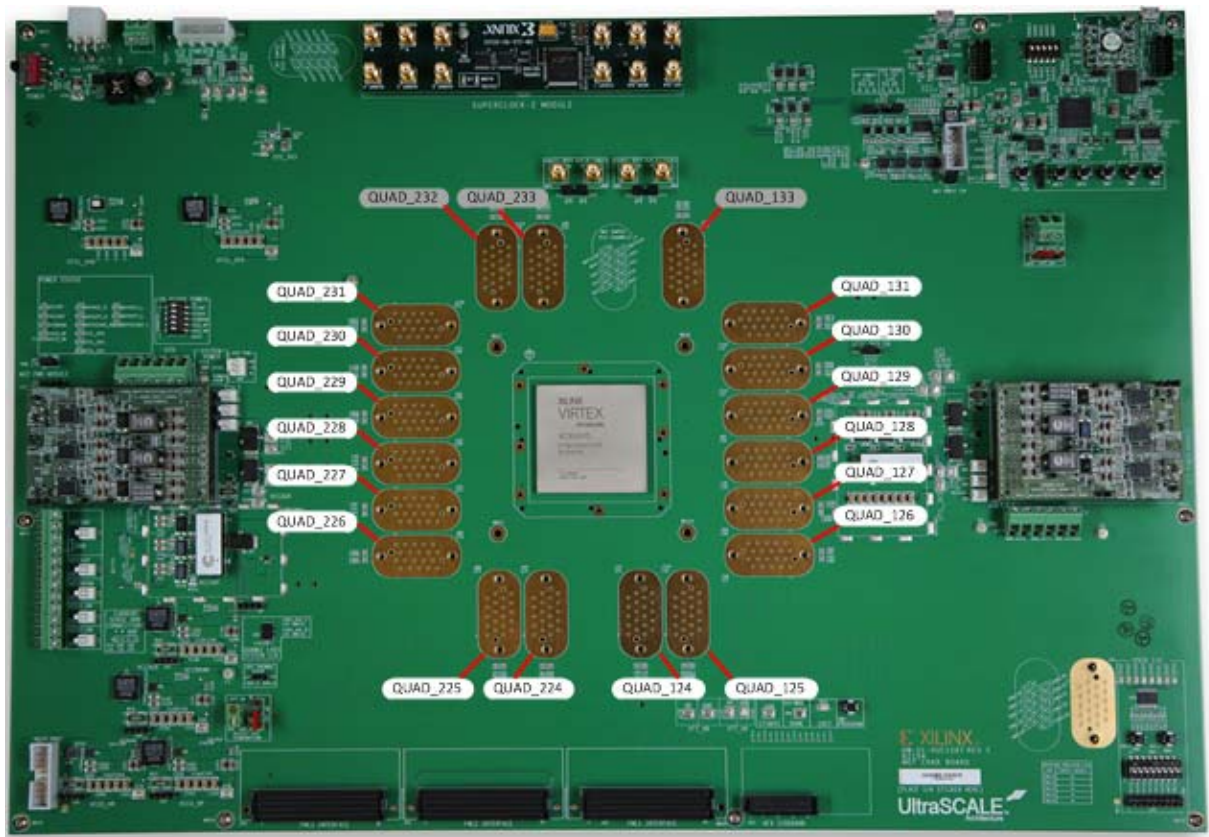
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Figure 1-1: **VCU1287 GTH and GTY Quad Locations**

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All multi-gigabit transceiver (MGT) pins and reference clock pins are routed from the FPGA to a connector pad that interfaces with Samtec Bulls Eye connectors. Figure 1-2 **A** shows the connector pad. Figure 1-2 **B** shows the connector pinout.
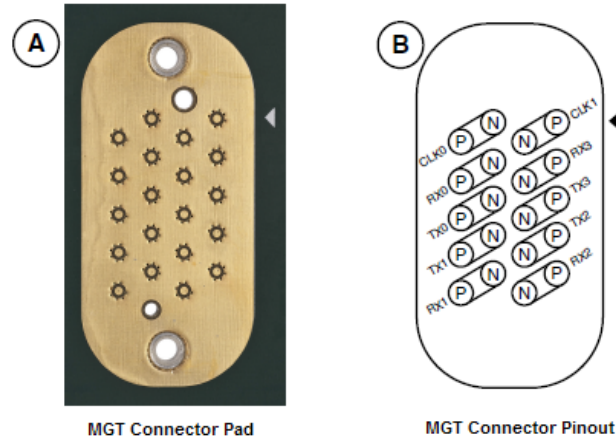
X15541-121416

Figure 1-2: **A—MGT Connector Pad. B—MGT Connector Pinout**

The SuperClock-2 module provides LVDS clock outputs for the MGT reference clocks in the IBERT demonstrations. Figure 1-3 shows the locations of the differential clock SMA connectors on the clock module which can be connected to the reference clock cables.
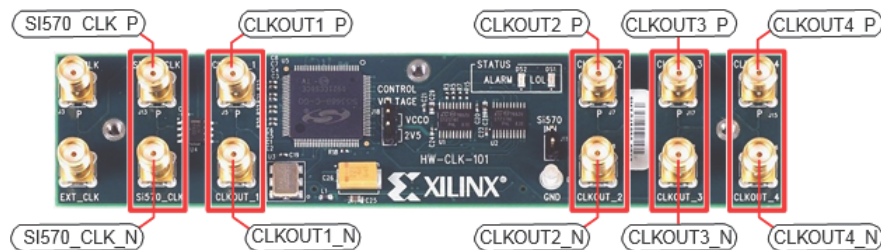
X15542-121416

Figure 1-3: **SuperClock-2 Module Output Clock SMA Locations**

The four SMA pairs labeled CLKOUT provide LVDS clock outputs from the Si5368 clock multiplier/jitter attenuator device on the clock module. The SMA pair labeled Si570_CLK provides LVDS clock output from the Si570 programmable oscillator on the clock module.

Note: The Si570 oscillator does not support LVDS output on the Rev B and earlier revisions of the SuperClock-2 module.

For more information on the SuperClock-2 module, see the *HW-CLK-101-SCLK2 SuperClock-2 Module User Guide* (UG770) [Ref 2].

Attaching the GTH Quad Connector

1. Before connecting the Bulls Eye cable assembly to the board, firmly secure the blue elastomer seal provided with the cable assembly to the bottom of the connector housing if it is not already inserted (see Figure 1-4).

Note: Figure 1-4 is for reference only and might not reflect the current version of the connector.

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Figure 1-4: **Bulls Eye Connector with Elastomer Seal**

2. Attach the Samtec Bulls Eye connector to GTH Quad 224 (Figure 1-5), aligning the two indexing pins on the bottom of the connector with the guide holes on the board. Hold the connector flush with the board and fasten it by tightening the two captive screws.
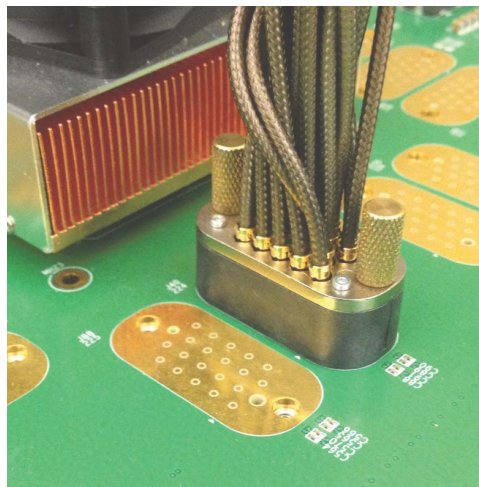
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Figure 1-5: **Bulls Eye Connector Attached to Quad 224**

GTH Transceiver Clock Connections

1. See Figure 1-2 to identify the P and N coax cables that are connected to the CLK0 reference clock inputs.

2. Connect these cables to the SuperClock-2 module as follows:

   ◦ CLK0_P coax cable → SMA connector J7 (CLKOUT1_P) on the SuperClock-2 module

   ◦ CLK0_N coax cable → SMA connector J8 (CLKOUT1_N) on the SuperClock-2 module

Note: Any one of the five differential outputs from the SuperClock-2 module can be used to source the GTH reference clock. CLKOUT1_P and CLKOUT1_N are used here as an example.

MGT TX/RX Loopback Connections

1. See Figure 1-2 to identify the P and N coax cables that are connected to the four receivers (RX0, RX1, RX2, and RX3) and the four transmitters (TX0, TX1, TX2, and TX3).

2. Use eight SMA female-to-female (F-F) adapters (Figure 1-6) to connect the transmit and receive cables as shown in Figure 1-7:

   ◦ TX0_P → SMA F-F Adapter → RX0_P

   ◦ TX0_N → SMA F-F Adapter → RX0_N

   ◦ TX1_P → SMA F-F Adapter → RX1_P

   ◦ TX1_N → SMA F-F Adapter → RX1_N

   ◦ TX2_P → SMA F-F Adapter → RX2_P

   ◦ TX2_N → SMA F-F Adapter → RX2_N

   ◦ TX3_P → SMA F-F Adapter → RX3_P

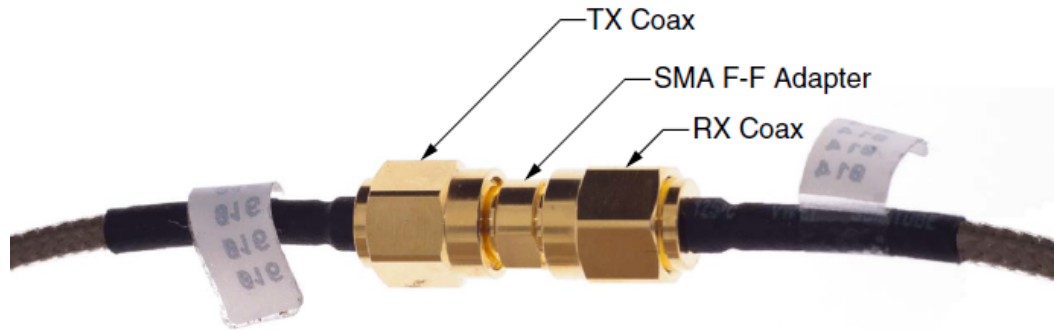   ◦ TX3_N → SMA F-F Adapter → RX3_N

RECOMMENDED: *To ensure good connectivity, it is recommended that the adapters be secured with a wrench; however, do not over-tighten the SMAs.*
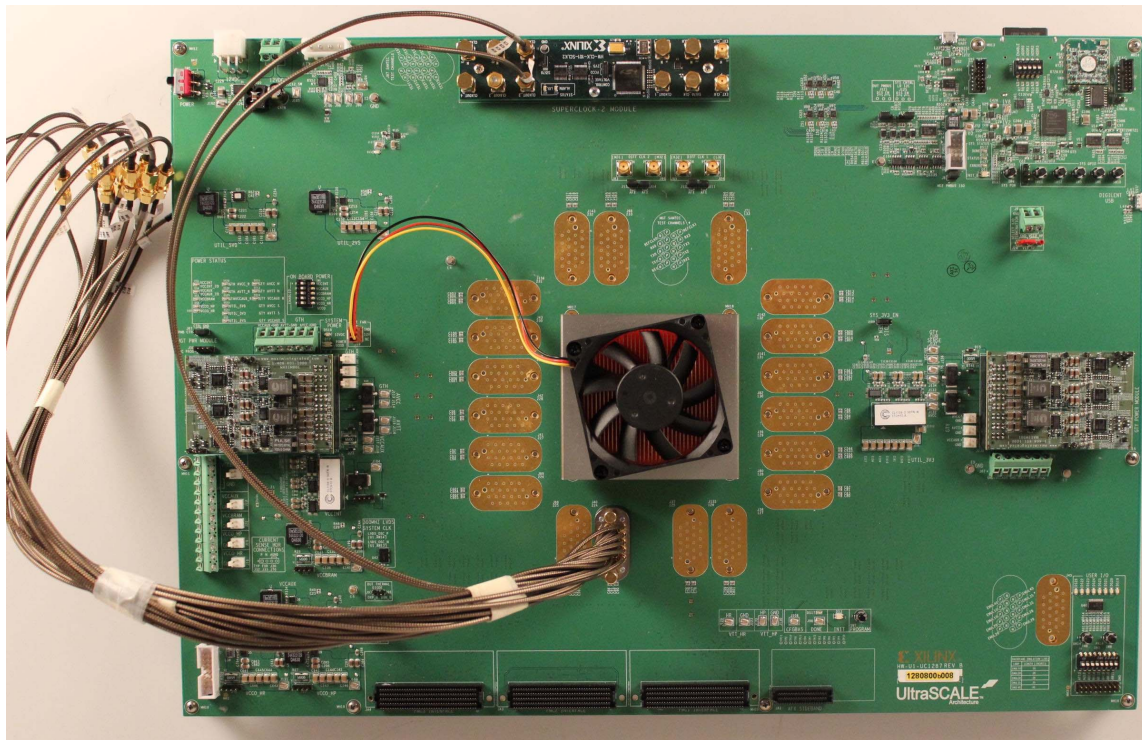

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Figure 1-6: **SMA F-F Adapter**

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Figure 1-7: **TX-to-RX Loopback Connection Example**

Figure 1-8 shows the VCU1287 board with the cable connections required for the Quad 224 GTH IBERT demonstration.

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Figure 1-8: **Cable Connections for Quad 224 GTH IBERT Demonstration**

Starting the SuperClock-2 Module

The SuperClock-2 module features two clock-source components:

- Always-on Si570 crystal oscillator

- Si5368 jitter-attenuating clock multiplier

Outputs from either source can be used to drive the transceiver reference clocks.

To start the SuperClock-2 module:

1. Configure the SuperClock-2 module using the Xilinx XC7Z010CLG225 Zynq-7000APSoC System Controller command line, which can be accessed through a serial communication terminal connection using the enhanced communication port of the Silicon Labs USB to Dual UART Bridge (Figure 1-9).

   Additional information about the Silicon Labs USB-to-UART is available in *Silicon Labs CP210x USB-to-UART Installation Guide* (UG1033) [Ref 3].

   Review the *VCU1287 Characterization Board User Guide* (UG1121) [Ref 1] for additional information about the System Controller.
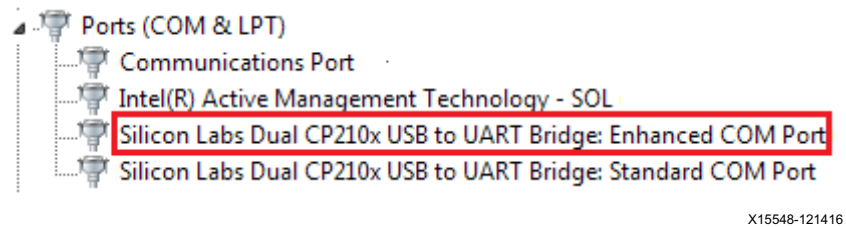

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Figure 1-9: **Silicon Labs Enhanced COM PORT**

2. Set the System Controller configuration DIP switches (SW13) to the OFF position (Figure 1-10). This disables configuration of the FPGA at power reset.
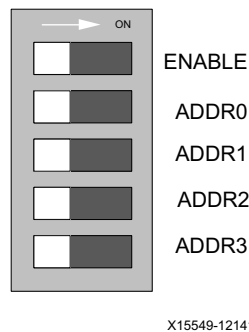

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*Figure 1-10:* **Configuration DIP Switch (SW13)**

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3. Connect J1 connector (USB/UART) on the VCU1287 board to the host computer using one of the standard-A plug to micro-B plug USB cables provided (Figure 1-11).

4. Power up the board by placing SW1 in the ON position.

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Figure 1-11:   **USB-UART Connector**

5. Open a serial communication terminal application on the host computer, for example "Hyper Terminal."

6. Connect to the port number associated with the **enhanced COM port** of the Silicon Lab USB-UART Bridge.

7. Set up a new connection as shown in Figure 1-12. Press **OK**.

8. Open the connection and press the **Return** key to view the **System Controller** options menu.
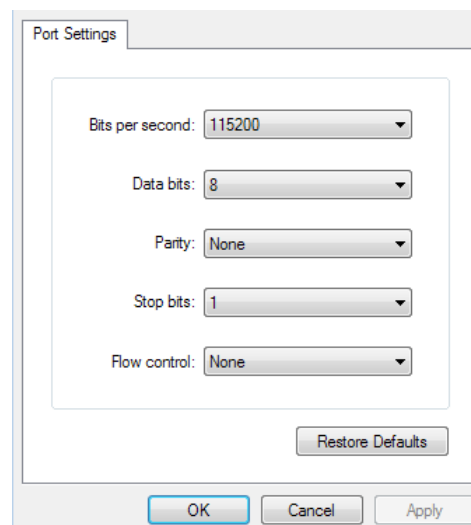
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Figure 1-12:   **Terminal Setting**

9. From the main **System Controller** menu, select option `1 Set Programmable Clocks` to access the SuperClock-2 options.

10. Select option `2 Set VCU1287 Si5368 Frequency` to set the output clock frequencies of the Si5368 clocks to 125 MHz.

11. Select option `2 Free-Run using XA-XB crystal` operating mode when prompted.

Configuring the FPGA

The Xilinx XC7Z010CLG225 Zynq-7000 AP SoC System Controller includes a System Integrated Configuration Engine (System ICE) option. The System ICE can be used to configure the FPGA, in 8-bit SMAP configuration mode, using one of the `*.bit` files provided on the SD card.

The FPGA can also be configured through the Vivado Design Suite using the `*.bit` files available on the SD card or online (as collection `rdf0368-vcu1287-ibert-2017-4.zip`) at Virtex UltraScale FPGA VCU1287 Characterization Kit documentation.

Review *UltraScale Architecture Configuration User Guide* (UG570) [Ref 4] for additional information about UltraScale device configuration.

1. Insert the SD card provided with the VCU1287 board into the SD card reader slot located on the bottom-side (upper-right corner) of the VCU1287 board.

2. From the main **System Controller** menu, select option `7 Configure UltraScale FPGA` to access the UltraScale FPGA configuration options:

3. Select option `1 Configure UltraScale FPGA from SD Card` to configure the FPGA from the SD card:

   The IBERT design demonstrations included with the SD cards can be selected using one of the bitstream numbers listed in Table 1-1.

Table 1-1: **IBERT Examples Bitstream Number**

IBERT Demonstration Design	Bitstream Number
QUAD_124	0
QUAD_125	1
QUAD_126	2
QUAD_127	3
QUAD_128	4
QUAD_129	5
QUAD_130	6
QUAD_131	7
QUAD_224	8
QUAD_225	9

Table 1-1: **IBERT Examples Bitstream Number** *(Cont'd)*

IBERT Demonstration Design	Bitstream Number
QUAD_226	10
QUAD_227	11
QUAD_228	12
QUAD_229	13
QUAD_230	14
QUAD_231	15

4. Select option (8) to configure the FPGA with the Quad 224 IBERT example design. Press **Enter** and review the terminal for configuration progress:

    Enter a Bitstream number (0-15):

    8

    Info: xilinx.sys opened

    Info: Opening rev_1/set8/config.def

    Info: Configuration definition file "rev_1/set8/config.def" opened

    Info: Clock divider is set to 2

    Info: Configuration clock frequency is 25MHz

    Info: Bitfile "rev_1/set8/vu95Q224.bit" opened

    ...10%...20%...30%...40%...50%...60%...70%...80%...90%...100%

    Configuration completed successfully

Setting Up the Vivado Design Suite for the GTH IBERT Demonstration

1. Connect the host computer to the VCU1287 board using the second standard-A plug to micro-B plug USB cable. The standard-A plug connects to a USB port on the host computer and the micro-B plug connects to J165 (the Digilent USB JTAG configuration port on the VCU1287 board) (Figure 1-13).
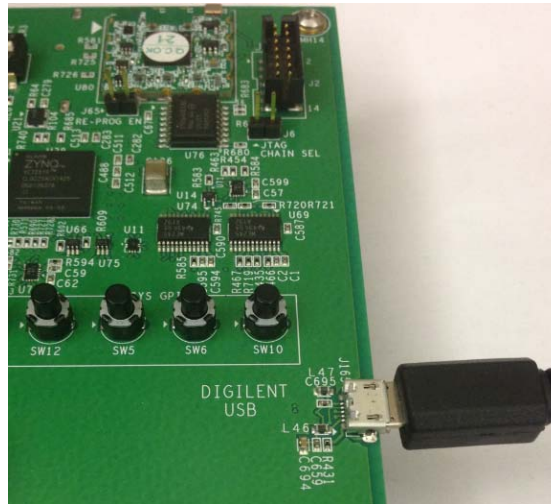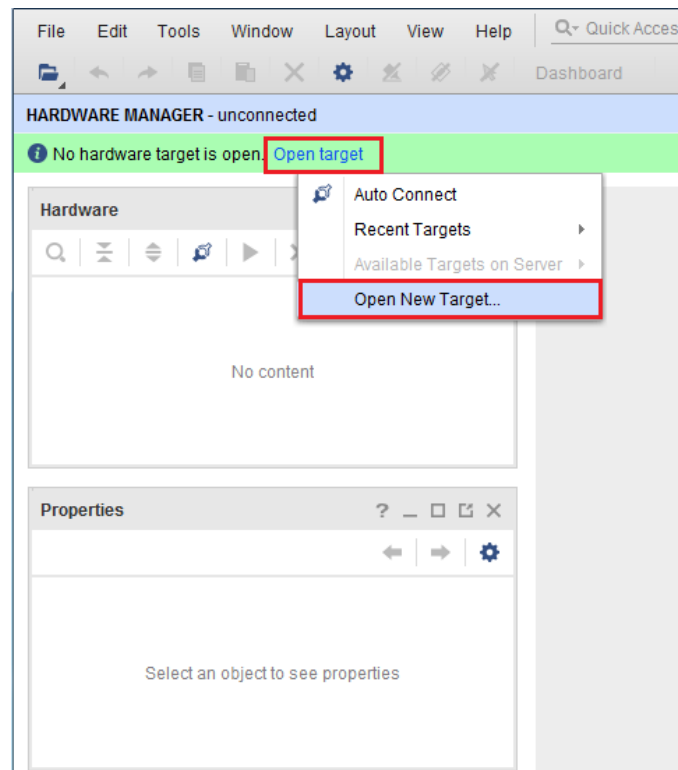

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Figure 1-13: **JTAG Connector**

2. Start the Vivado Design Suite on the host computer and click **Flow > Open Hardware Manager** (highlighted in Figure 1-14).
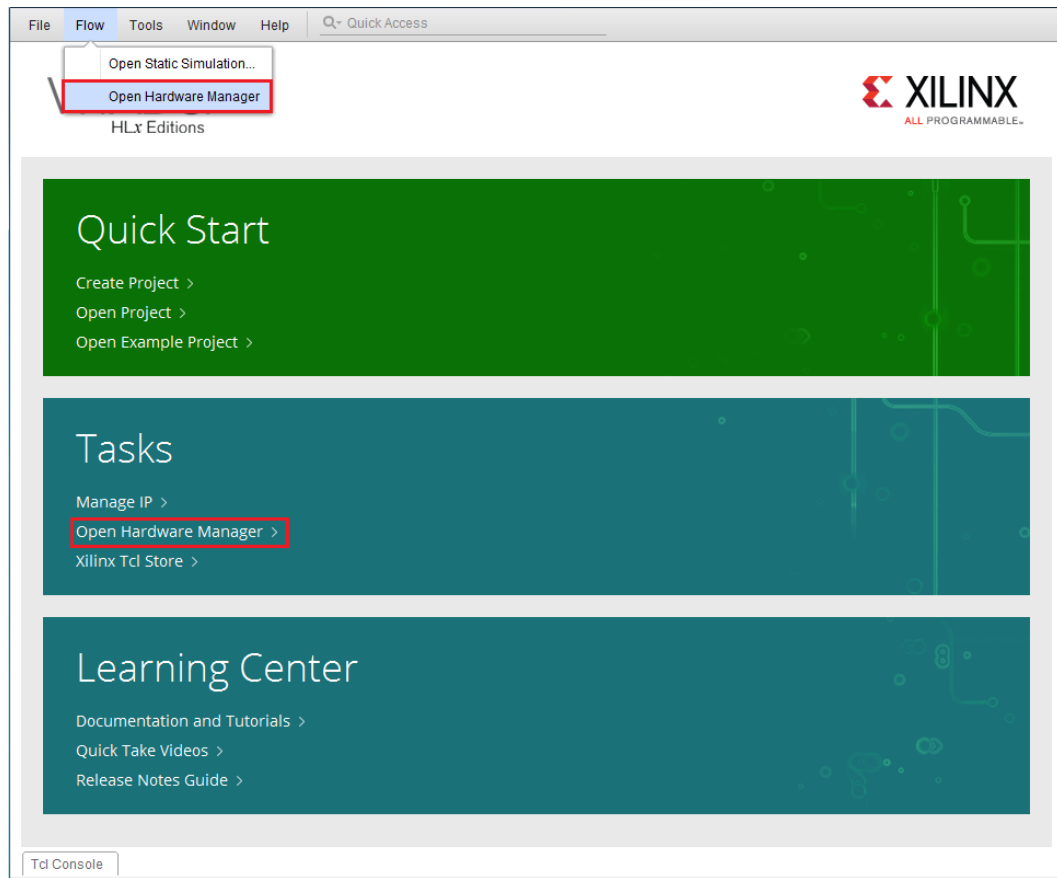
Figure 1-14: **Vivado Design Suite, Open Hardware Manager**

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3. In the Hardware Manager window (Figure 1-15), click **Open New Target**.

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Figure 1-15: **Open a New Hardware Manager**

4. In the Hardware Server Settings window, select **Local server (target is on local machine)**. Click **Next**.

5. In the Select Hardware Target window, the **xilinx_tcf** cable appears under **Hardware Targets**, and the JTAG chain contents of the selected cable appear under **Hardware Devices** (Figure 1-16). Select the **xilinx_tcf_Digilent** target and keep the JTAG Clock Frequency at the default value (**15 MHz**). Click **Next**.
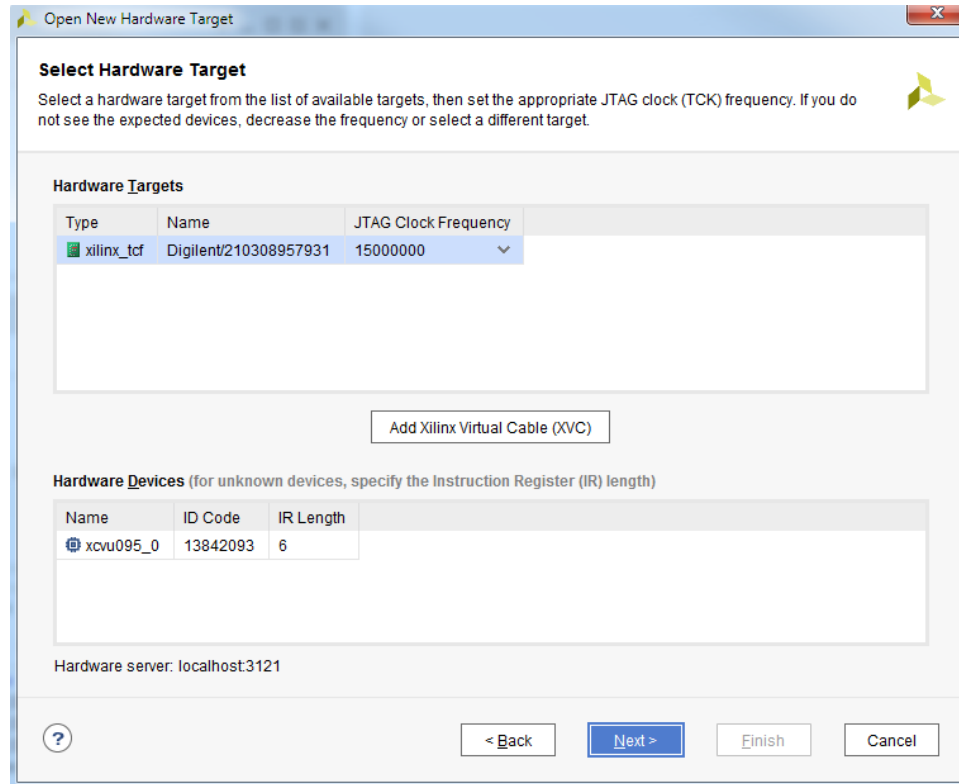

Figure 1-16: **Select Hardware Target**

6. In the Open Hardware Target Summary window, click **Finish**. The wizard closes and the Vivado Design Suite opens the hardware target.

7. To view the GTH transceiver operation, click **Layout > Serial I/O Analyzer**. From the top of the Hardware Manager window, select **Auto-Detect Links** to display all available links automatically. Links can also be created manually in the Links window by right-clicking and selecting **Create Links** or by clicking the **Create Links** button (Figure 1-17).
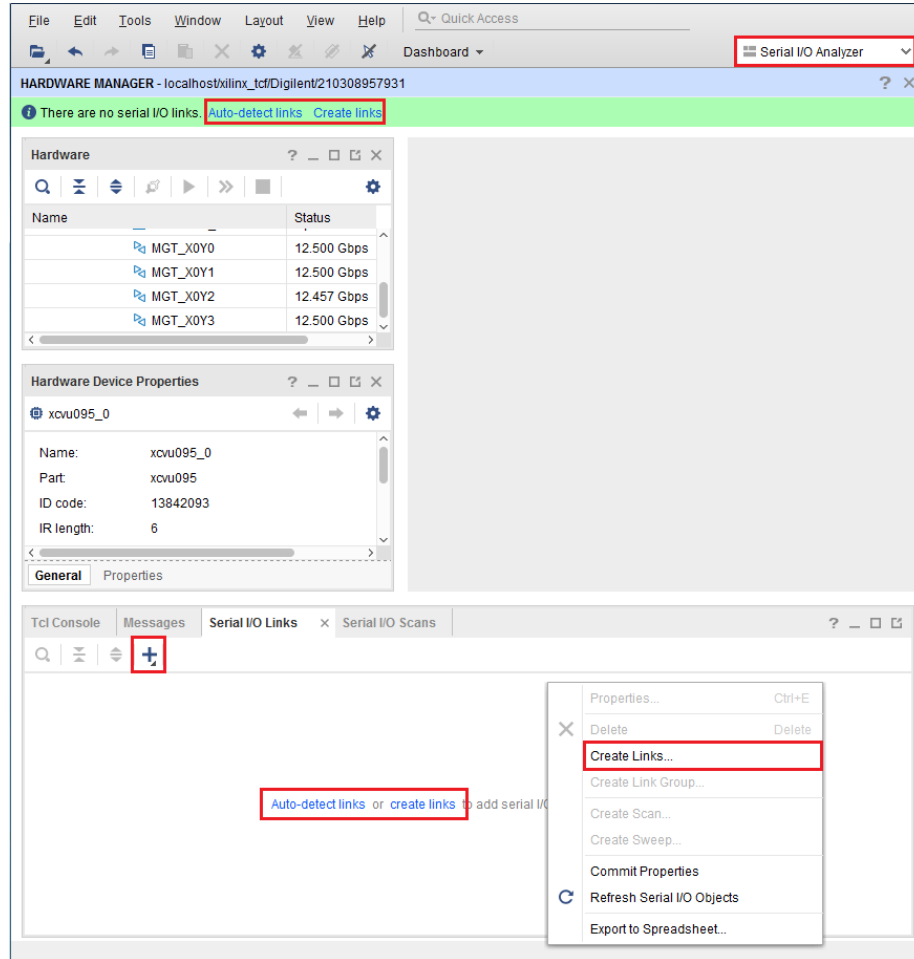
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Figure 1-17: **Serial I/O Analyzer – Create Links**

If links are created manually, the Create Links window is displayed (Figure 1-18). The options in this window are used to link any TX GT to any RX GT.

8. To create links, select the TX GT and RX GT from the two lists, then click the **Add (+)** button. For this project, connect the following links (Figure 1-18):

- MGT_X0Y0/TX (xcvu095_0/Quad_224) to MGT_X0Y0/RX (xcvu095_0/Quad_224)

- MGT_X0Y1/TX (xcvu095_0/Quad_224) to MGT_X0Y1/RX (xcvu095_0/Quad_224)

- MGT_X0Y2/TX (xcvu095_0/Quad_224) to MGT_X0Y2/RX (xcvu095_0/Quad_224)

- MGT_X0Y3/TX (xcvu095_0/Quad_224) to MGT_X0Y3/RX (xcvu095_0/Quad_224)
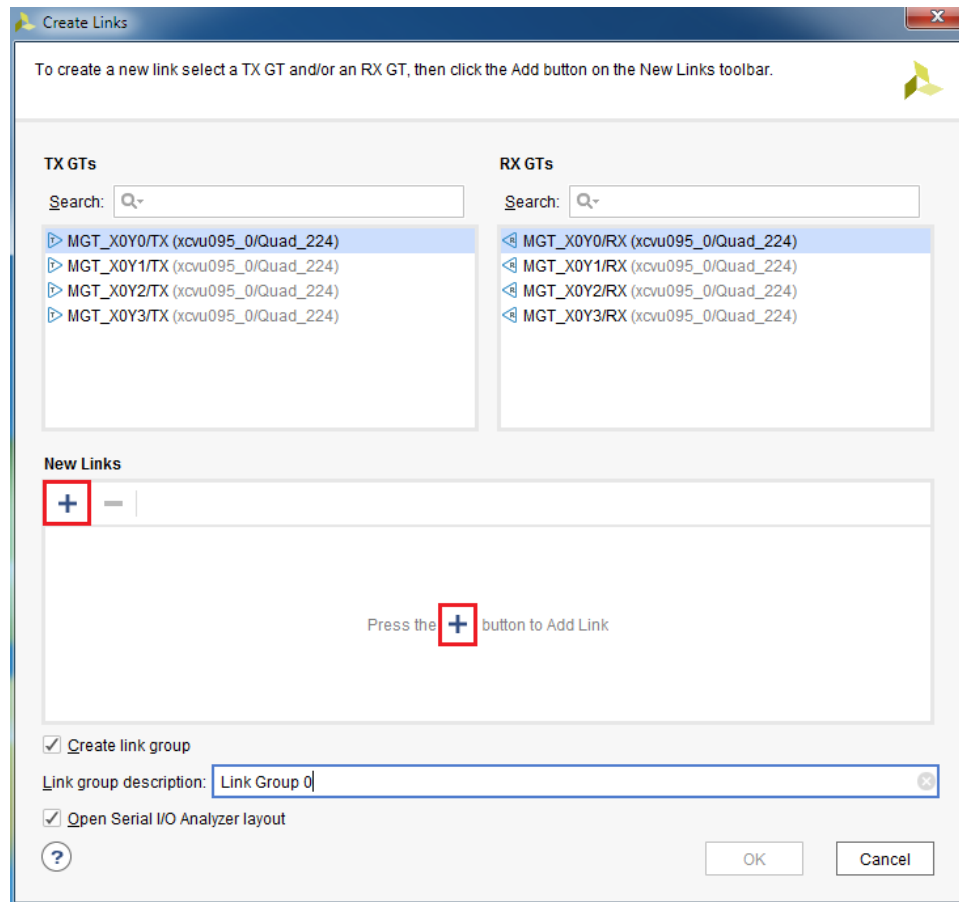
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Figure 1-18: **Create Links Window**

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Viewing GTH Transceiver Operation

After completing Setting Up the Vivado Design Suite for the GTH IBERT Demonstration, the IBERT demonstration is configured and running. The status and test settings are displayed on the Serial I/O Links tab shown in Figure 1-19.

Review the line rate and RX bit error count. The line rate for all four GTH transceivers is 12.5 Gb/s (see the Stataus column in Figure 1-19). Verify that the there are no bit errors.
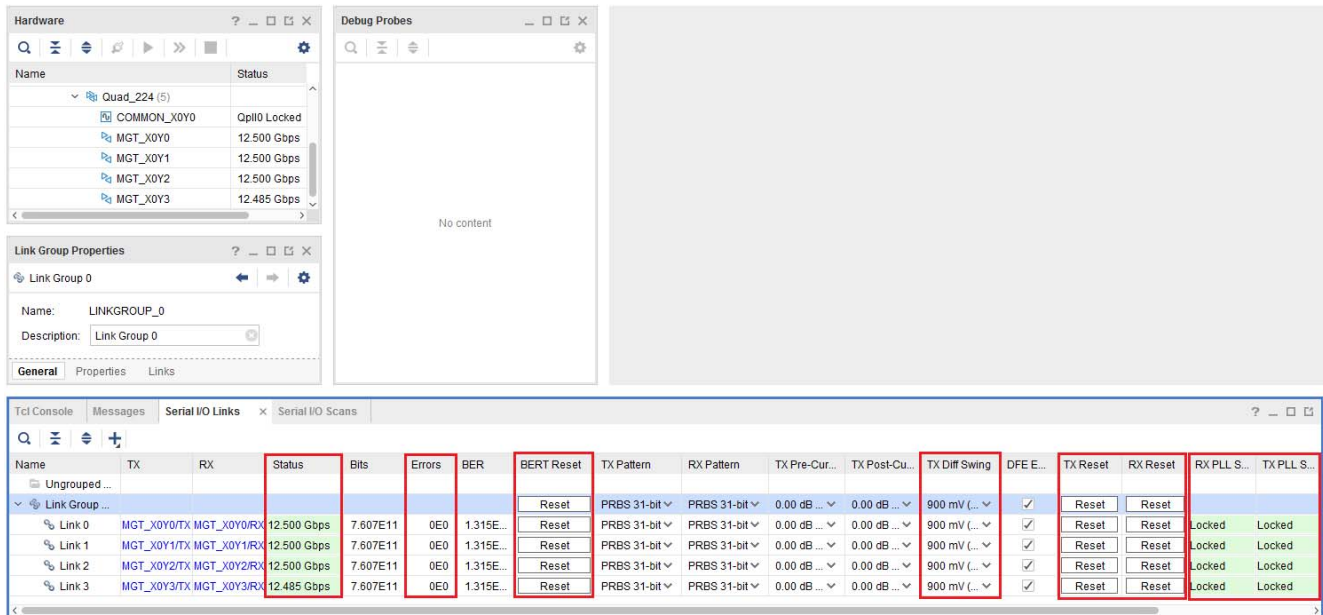
X15559-040717

Figure 1-19: **Serial I/O Analyzer Links**

In Case of RX Bit Errors

If there are initial bit errors after linking, or as a result of changing the TX or RX pattern, click the respective **BERT Reset** button to zero the count.

If the MGT Link **Status** shows `No Link` for one or more transceivers:

- Make sure the blue elastomer seal is connected to the bottom of the Bulls Eye cable (Figure 1-4) and the cable is firmly connected and flush on the board.

- Increase the TX differential swing of the transceiver (to compensate for any loss due to PCB process variation).

- Click the respective **TX Reset** button followed by **BERT Reset**.

Additional information on the Vivado Design Suite and IBERT core can be found in *Vivado Design Suite User Guide: Programming and Debugging* (UG908) [Ref 5] and in *Integrated Bit Error Ratio Tester 7 Series GTX Transceivers: LogiCORE IP Product Guide* (PG132) [Ref 7].

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Closing the IBERT Demonstration

To stop the IBERT demonstration:

1. Close the Vivado Design Suite by selecting **File > Exit**.

2. Place the main power switch SW1 in the OFF position.

Running the GTY IBERT Demonstration

The GTY IBERT demonstration operates one GTY Quad at a time. This section describes how to test GTY Quad 124. The remaining GTY Quads can be tested following a similar series of steps.

Connecting the GTY Transceivers and Reference Clocks

Review Figure 1-1 for the location of the GTY transceiver Quads on the VCU1287 board.

All GTY transceiver pins and reference clock pins are routed from the FPGA to a connector pad that interfaces with Samtec Bulls Eye connectors. Review Figure 1-2 for the pinout of the MGT Bulls Eye connector pad.

Attach the GTY Quad Connector

1. Before connecting the Bulls Eye cable assembly to the board, firmly secure the blue elastomer seal provided with the cable assembly to the bottom of the connector housing if it is not already inserted (see Figure 1-4).

2. Attach the Samtec Bulls Eye connector to GTY Quad 124 (Figure 1-20), aligning the two indexing pins on the bottom of the connector with the guide holes on the board. Hold the connector flush with the board and fasten it by tightening the two captive screws.
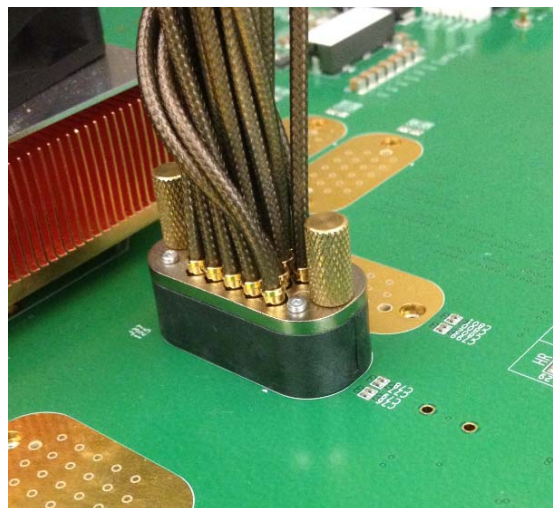
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Figure 1-20: **Bulls Eye Connector Attached to Quad 124**

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GTY Transceiver Clock Connections

1. Refer to Figure 1-2 to identify the P and N coax cables that are connected to the CLK0 reference clock inputs.

2. Connect these cables to the SuperClock-2 module as follows:

• CLK0_P coax cable → SMA connector J7 (CLKOUT1_P) on the SuperClock-2 module

• CLK0_N coax cable → SMA connector J8 (CLKOUT1_N) on the SuperClock-2 module

Note: Any one of the five differential outputs from the SuperClock-2 module can be used to source the GTY reference clock. CLKOUT1_P and CLKOUT1_N are used here as an example.

GTY TX/RX Loopback Connections

1. Refer to Figure 1-2 to identify the P and N coax cables that are connected to the four receivers (RX0, RX1, RX2, and RX3) and the four transmitters (TX0, TX1, TX2,and TX3).

2. Use eight SMA female-to-female (F-F) adapters (Figure 1-6) to connect the transmit and receive cables as shown in Figure 1-7:

• TX0_P → SMA F-F Adapter → RX0_P

• TX0_N → SMA F-F Adapter → RX0_N

• TX1_P → SMA F-F Adapter → RX1_P

• TX1_N → SMA F-F Adapter → RX1_N

• TX2_P → SMA F-F Adapter → RX2_P

• TX2_N → SMA F-F Adapter → RX2_N

• TX3_P → SMA F-F Adapter → RX3_P

• TX3_N → SMA F-F Adapter → RX3_N

RECOMMENDED: To ensure good connectivity, it is recommended that the adapters be secured with a wrench; however, do not over tighten the SMAs.

Figure 1-21 shows the VCU1287 board with the cable connections required for the Quad 124 GTY IBERT demonstration.
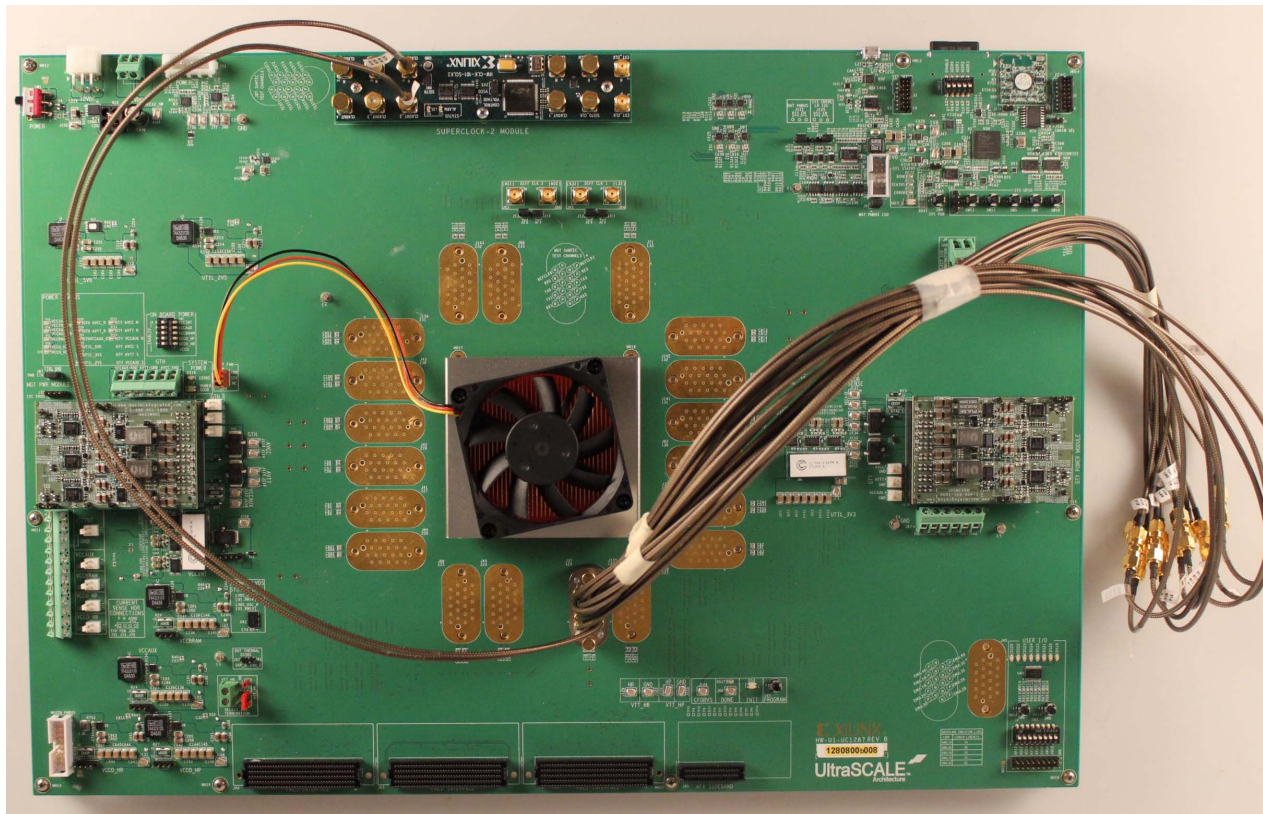
X15561-121416

Figure 1-21:   **Cable Connections for Quad 124 GTY IBERT Demonstration**

Starting the SuperClock-2 Module

The SuperClock-2 module provides LVDS clock outputs for the GTH and GTY transceivers reference clock in the IBERT demonstration. For both of the GTH and GTY IBERT demonstrations, the output clock frequency is preset to 125.00 MHz. See the description for Starting the SuperClock-2 Module, for more details.

Configuring the FPGA

Similar to the GTH IBERT example, the VCU1287 board can be configured using the onboard Xilinx XC7Z010CLG225 Zynq-7000APSoC System Integrated Configuration Engine (SystemICE) in 8-bit SMAP configuration mode. Or the FPGA can be configured through the Vivado Design Suite using the `*.bit` files available on the SD card and online (as collection `rdf0368-vcu1287-ibert-2017-4.zip`) at Virtex UltraScale FPGA VCU1287 Characterization Kit documentation.

Review *UltraScale Architecture Configuration User Guide* (UG570) [Ref 4] for additional information about the UltraScale device configuration.

1. Insert the SD card provided with the VCU1287 board into the SD card connector located on the bottom-side (upper-right corner) of the VCU1287 board.

2. From the main **System Controller** menu, select option (7) **Configure UltraScale FPGA** to access the UltraScale FPGA configuration options.

3. Select option (1) **Configure UltraScale FPGA from SD Card** to configure the FPGA from the SD card.

4. Select option (0) to configure the FPGA with the Quad 124 IBERT example design. Press **Enter** and review the terminal for configuration progress.

   Enter a Bitstream number (0-15):

   0

   Info : xilinx.sys opened

   Info : Opening rev_1/set0/config.def

   Info : Configuration definition file "rev_1/set0/config.def" opened

   Info : Clock divider is set to 2

   Info : Configuration clock frequency is 25MHz

   Info : Bitfile "rev_1/set0/vu95Q124.bit" opened

   ...10%...20%...30%...40%...50%...60%...70%...80%...90%...100%

   Configuration completed successfully

Setting Up the Vivado Design Suite for the GTY IBERT Demonstration

1. Connect the host computer to the VCU1287 board using the second standard-A plug to micro-B plug USB cable. The standard-A plug connects to a USB port on the host computer and the micro-B plug connects to J165 (the Digilent USB JTAG configuration port on the VCU1287 board) (Figure 1-13).

2. Start the Vivado Design Suite on the host computer and click **Flow > Open Hardware Manager**.

3. In the Hardware Manager window, click **Open New Target**.

4. In the Hardware Server Settings window, select Local server (target is on local machine). Click Next.

5. In the Select Hardware Target window, the xilinx_tcf cable appears under Hardware Targets, and the JTAG chain contents of the selected cable appear under Hardware Devices. Select the **xilinx_tcf_Digilent** target and keep the JTAG Clock Frequency at the default value (**15 MHz**), click **Next**.

6. In the Open Hardware Target Summary window, click **Finish**. The wizard closes and the Vivado Design Suite opens the hardware target.

7. To view the GTY transceiver operation, click **Layout > Serial I/O Analyzer**. From the top of the Hardware Manager window, select **Auto-Detect Links** to display all available links automatically. Links can also be created manually in the Links window by right-clicking and selecting **Create Links**, or by clicking the **Create Links** button (Figure 1-22).
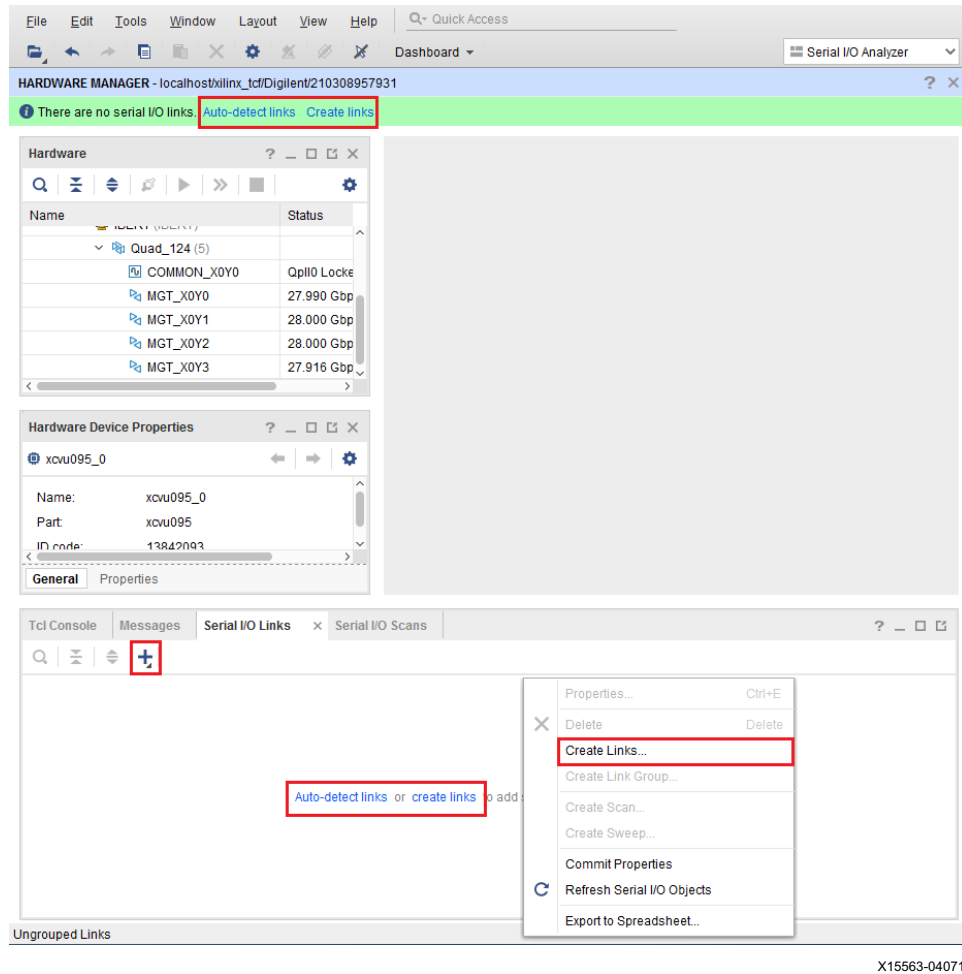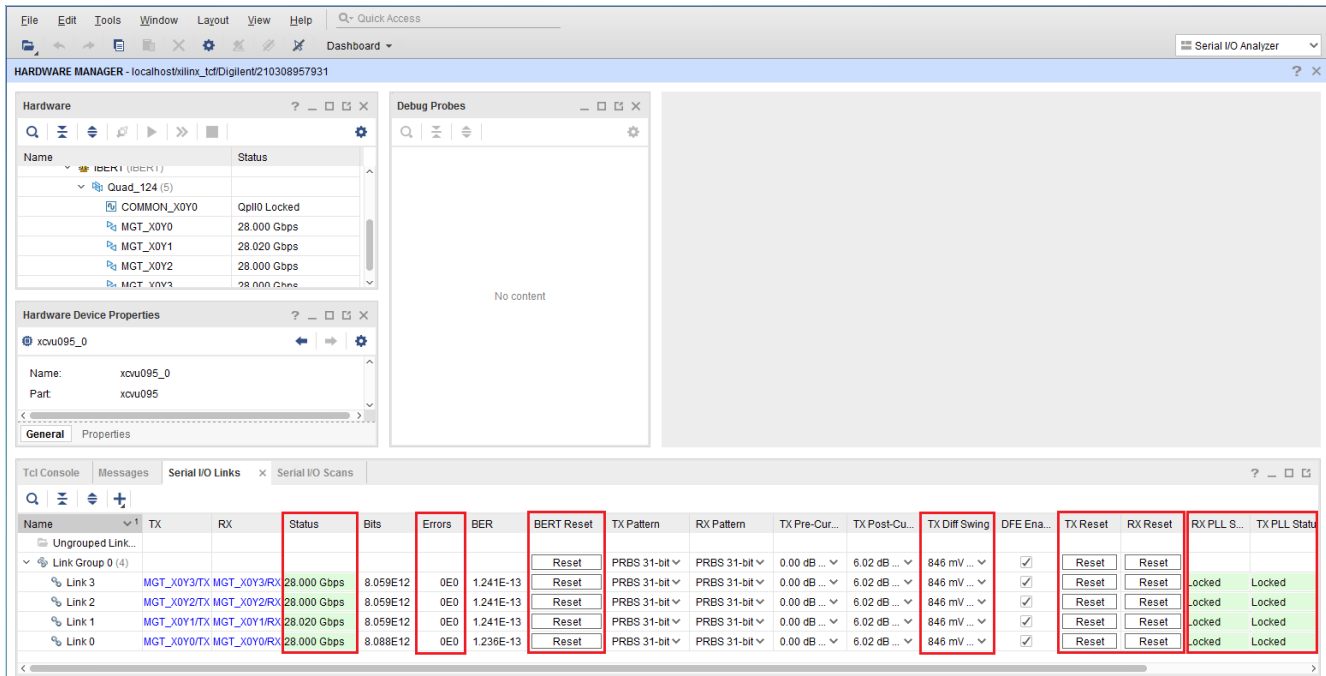

Figure 1-22: **Serial I/O Analyzer - Create Links**

8. Use the **Create Links** window to manually link the TX transceiver and RX transceiver.

9. If links are created manually, the Create Links window is displayed. The options in this window are used to link any TX GT to any RX GT. To create links, select the TX GT and RX GT from the two lists, then click the **Add (+)** button. For this project, connect the following links:

   ◦ MGT_X0Y0/TX (xcvu095_0/Quad_124) to MGT_X0Y0/RX (xcvu095_0/Quad_124)

   ◦ MGT_X0Y1/TX (xcvu095_0/Quad_124) to MGT_X0Y1/RX (xcvu095_0/Quad_124)

   ◦ MGT_X0Y2/TX (xcvu095_0/Quad_124) to MGT_X0Y2/RX (xcvu095_0/Quad_124)

   ◦ MGT_X0Y3/TX (xcvu095_0/Quad_124) to MGT_X0Y3/RX (xcvu095_0/Quad_124)

Viewing GTY Transceiver Operation

After completing Setting Up the Vivado Design Suite for the GTY IBERT Demonstration, the IBERT demonstration is configured and running. The status and test settings are displayed on the Serial I/O Links tab shown in Figure 1-23.

Review the line rate and RX bit error count. The line rate for all four GTY transceivers is 28.0 Gb/s (see the Status column in Figure 1-23). Verify that the there are no bit errors.

X15565-040717

Figure 1-23: **Serial I/O Analyzer Links**

In Case of RX Bit Errors

If there are initial bit errors after linking, or as a result of changing the TX or RX pattern, click the respective **BERT Reset** button to zero the count.

If the MGT Link **Status** shows No Link for one or more transceivers:

- Make sure the blue elastomer seal is connected to the bottom of the Bulls Eye cable and the cable is firmly connected and flush on the board.

- Increase the TX differential swing of the transceiver (to compensate for any loss due to PCB process variation).

- Click the respective **TX Reset** button followed by **BERT Reset.**

Send Feedback

Additional information on the Vivado Design Suite and IBERT core can be found in *Vivado Design Suite User Guide: Programming and Debugging* (UG908) [Ref 5] and in *Integrated Bit Error Ratio Tester 7 Series GTX Transceivers: LogiCORE IP Product Guide* (PG132) [Ref 7].

Closing the IBERT Demonstration

To stop the IBERT demonstration:

1. Close the Vivado Design Suite by selecting **File > Exit.**

2. Place the main power switch SW1 in the off position.

Creating the IBERT Cores

Creating the GTH IBERT Core

The Vivado® Design Suite 2017.4 is required to rebuild the designs shown here.

This section provides a procedure to create a single Quad GTH IBERT core. The procedure assumes Quad 224 at 12.5 Gb/s line rate, but cores for any of the GTH Quads with any supported line rate can be created following the same series of steps.

For more details on generating IBERT cores, see the *Vivado Design Suite User Guide: Programming and Debugging* (UG908) [Ref 5].

1. Start the Vivado Design Suite.

2. In the Vivado Design Suite window, click **Manage IP** (highlighted in Figure 2-1) and select **New IP Location**.
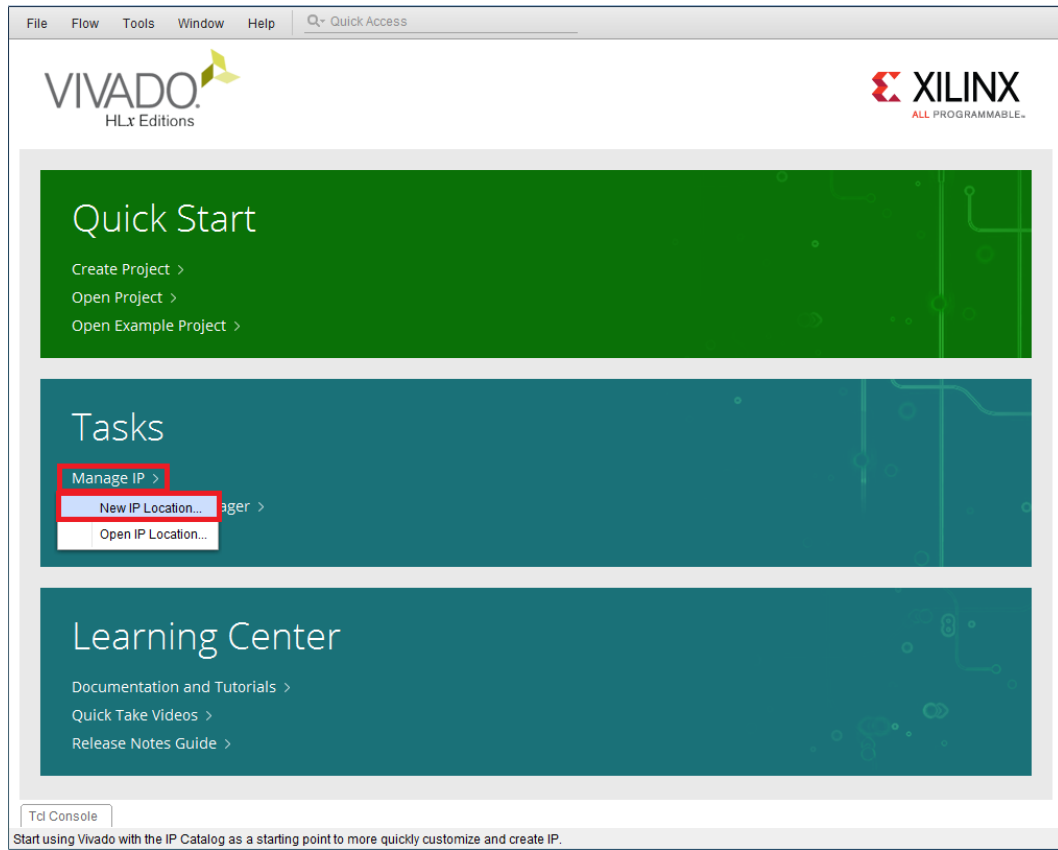
Figure 2-1: **Vivado Design Suite Initial Window**

3. In the Manage IP Settings window, click the **(…)** button next to the Part field to select the target part. Use the drop-down menu items to filter the devices. Select the **xcvu095-ffvb2104-3-e** device (see Figure 2-2). Click **OK**.
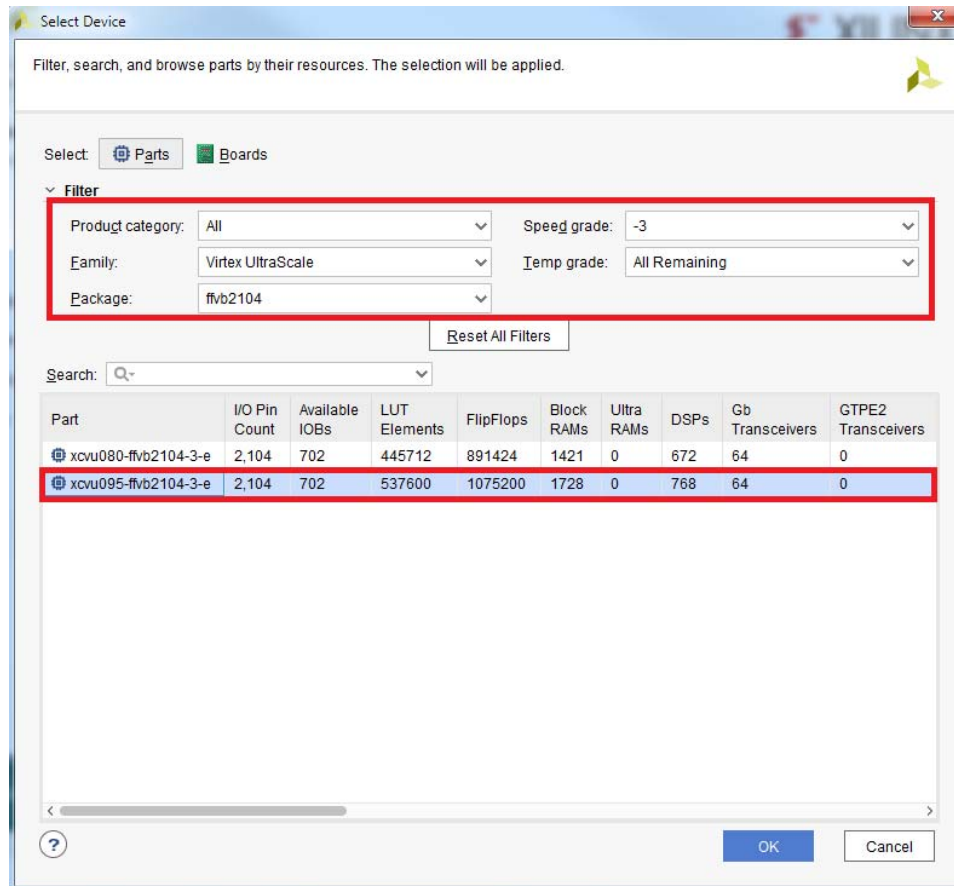
X18865-041017

Figure 2-2: **Select Device**

4. Back on the Manage IP window, select **Verilog** for Target language, **Vivado Simulator** for Target simulator, **Mixed** for Simulator language, and a directory to save the customized IP (Figure 2-3). Click **Finish**.

Note: Make sure the directory name does not include spaces.
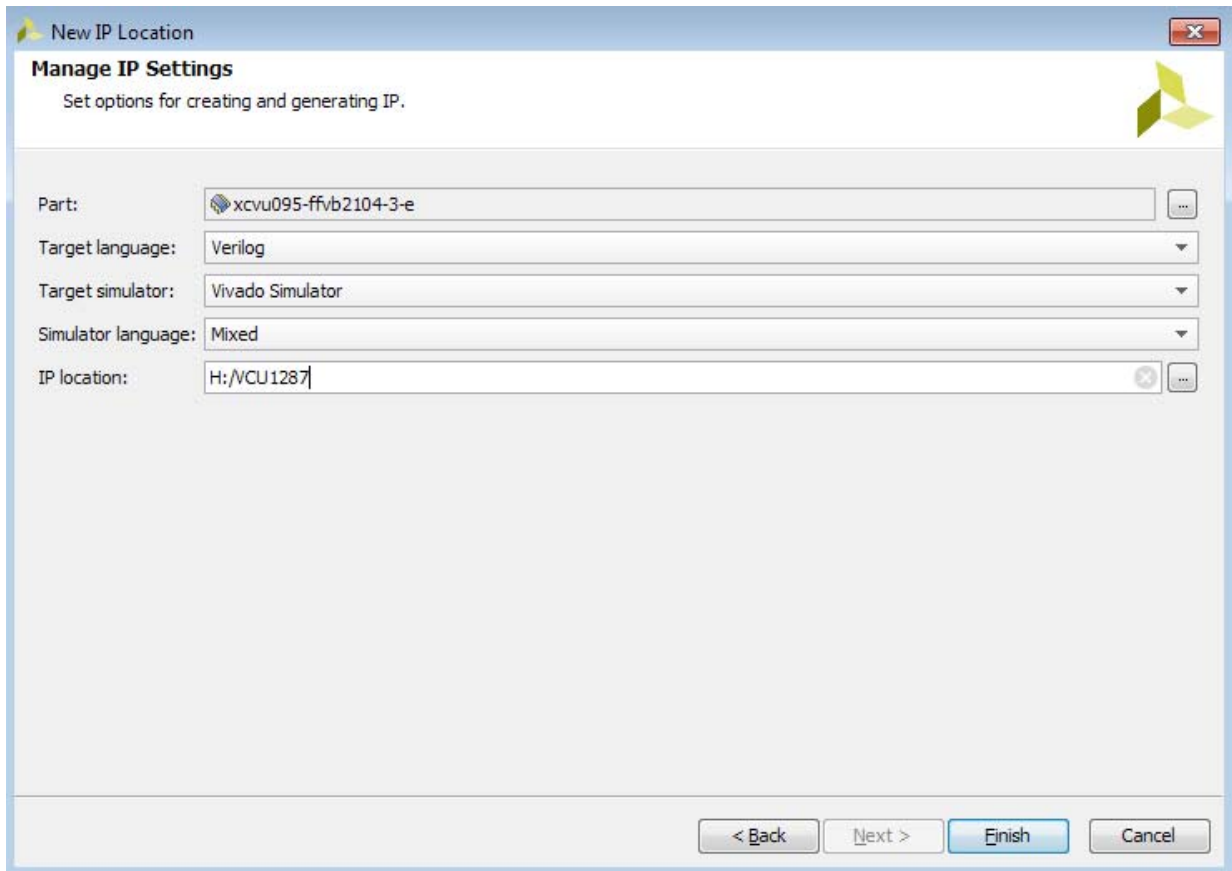
X15568-121416

Figure 2-3: **Manage IP Settings**

5. In the IP Catalog window, expand the Debug & Verification folder, expand the Debug folder, and double-click **IBERT UltraScale GTH** (Figure 2-4).
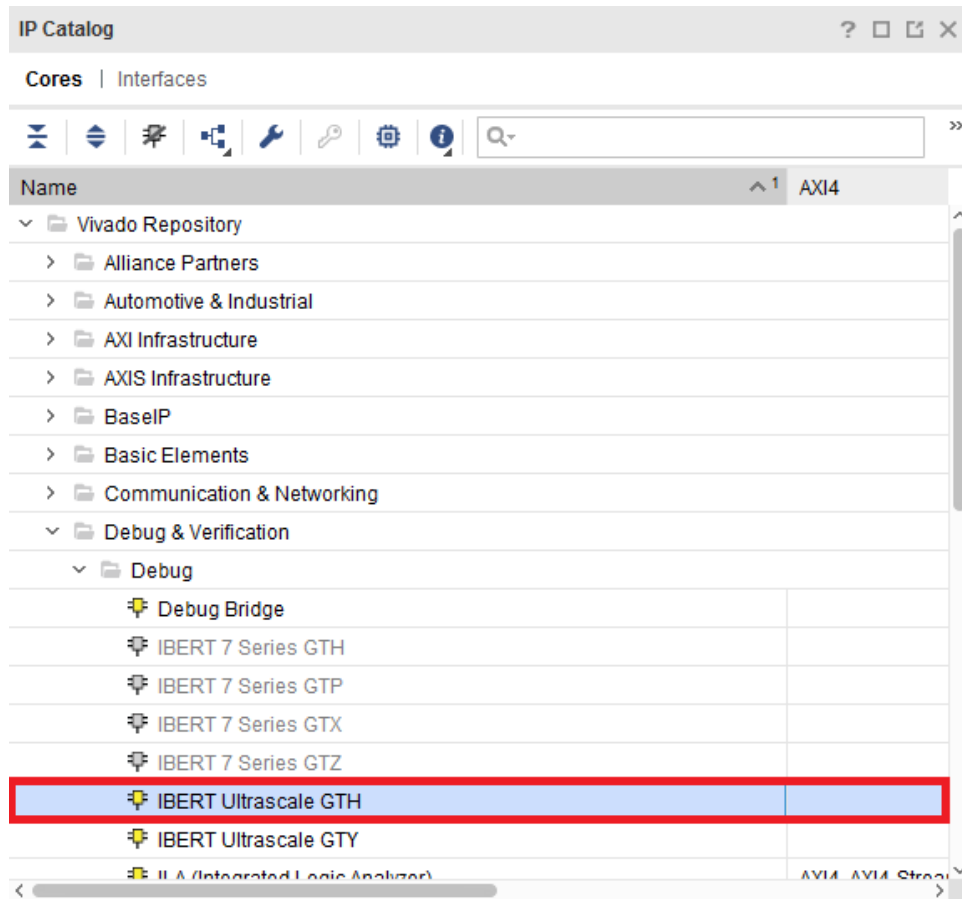
Figure 2-4: **IP Catalog**

...

6. A Customize IP window opens. In the Protocol Definition tab, set the LineRate(Gbps) to **12.5**. Change Refclk(MHz) to **125**. Keep defaults for other fields (Figure 2-5).
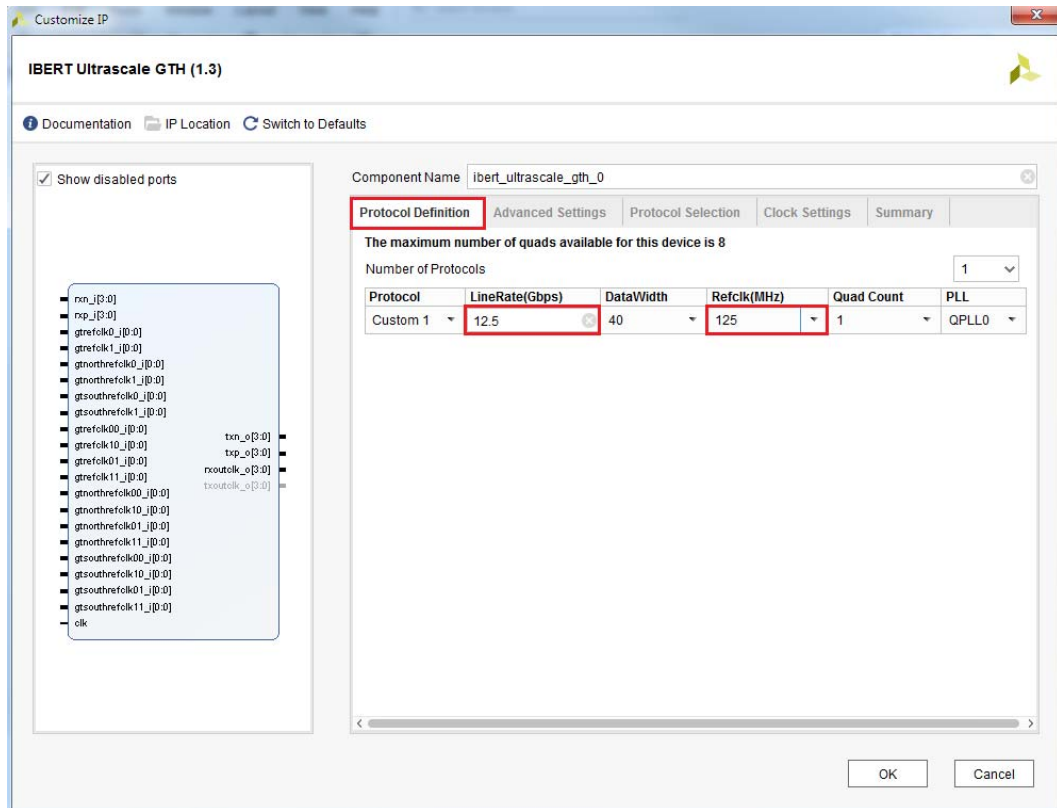
X18868-041017

Figure 2-5:   **Customize IP — Protocol Definition**

7. In the Protocol Selection tab, use the Protocol Selected drop-down menu next to QUAD_224 to select **Custom 1/12.5 Gb/s** and select **MGTREFCLK0 224** from the REFCLK Selection menu (Figure 2-6).
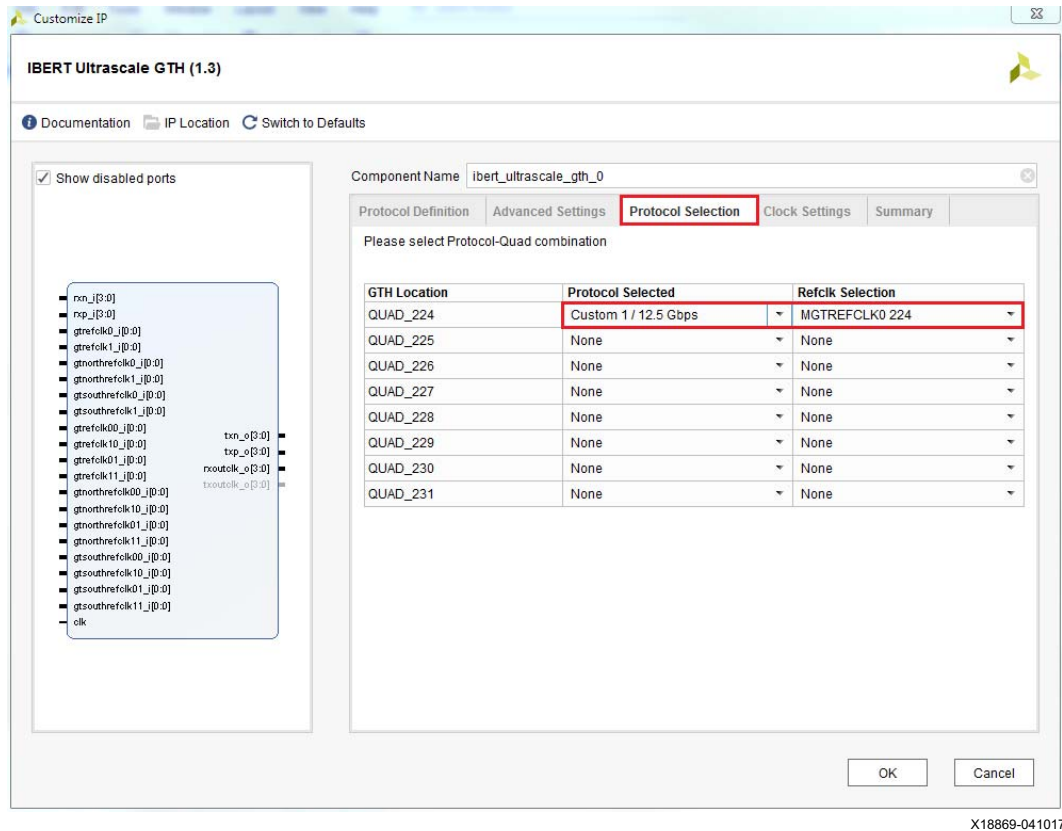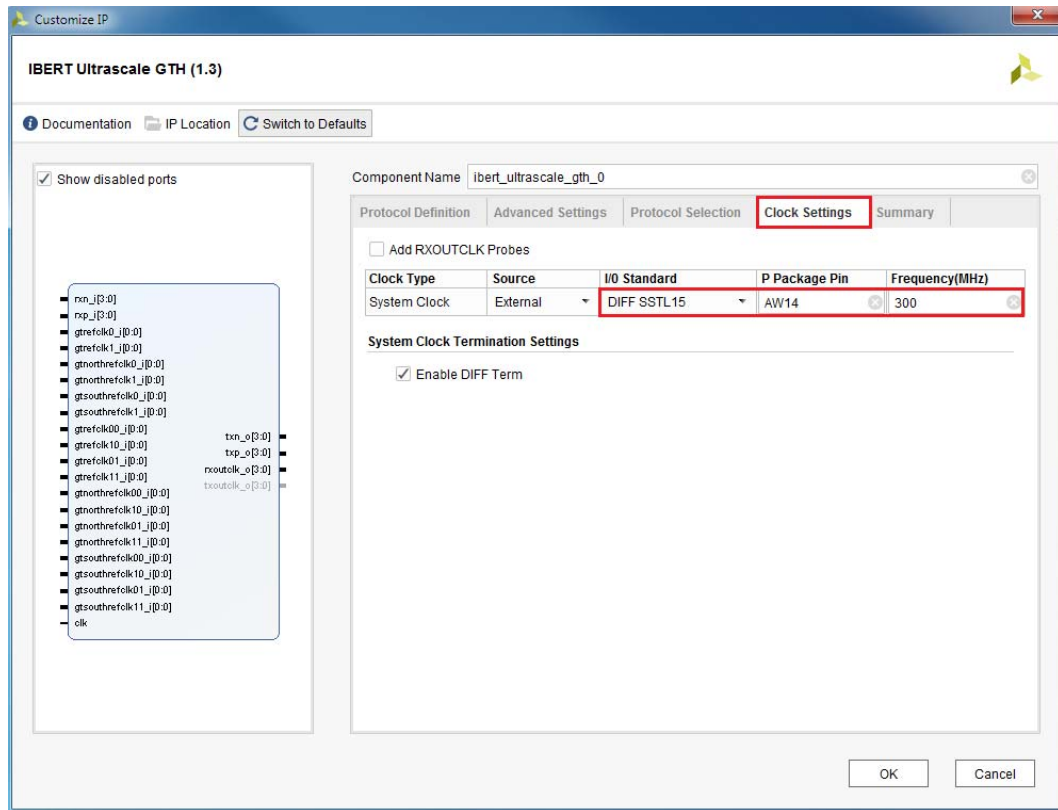

*Figure 2-6:* **Customize IP — Protocol Selection**

Send Feedback

8. In the Clock Settings tab, select **DIFF SSTL15** for the I/O Standard, enter **AW14** for the P Package Pin (the FPGA pins to which the system clock is connected), and make sure the Frequency (MHz) is set to **300** (Figure 2-7). Click **OK**.

X18870-041017

Figure 2-7: **Customize IP — Clock Settings**

Send Feedback

9. Select the **Global Synthesis** option and click **Generate** to generate the output product (Figure 2-8).
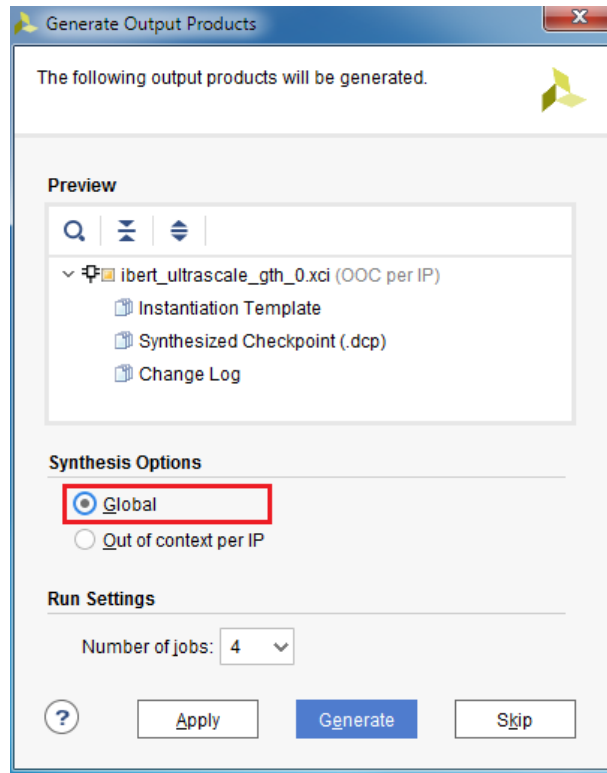
X18871-041017

Figure 2-8: **Generate Output Products**

10. From the Project Manager window, in the Sources window, right-click the **IBERT IP** and select **Open IP Example Design** (Figure 2-9). Specify a location to save the design, click **OK**, and the example design launches in a new Vivado Design Suite window.
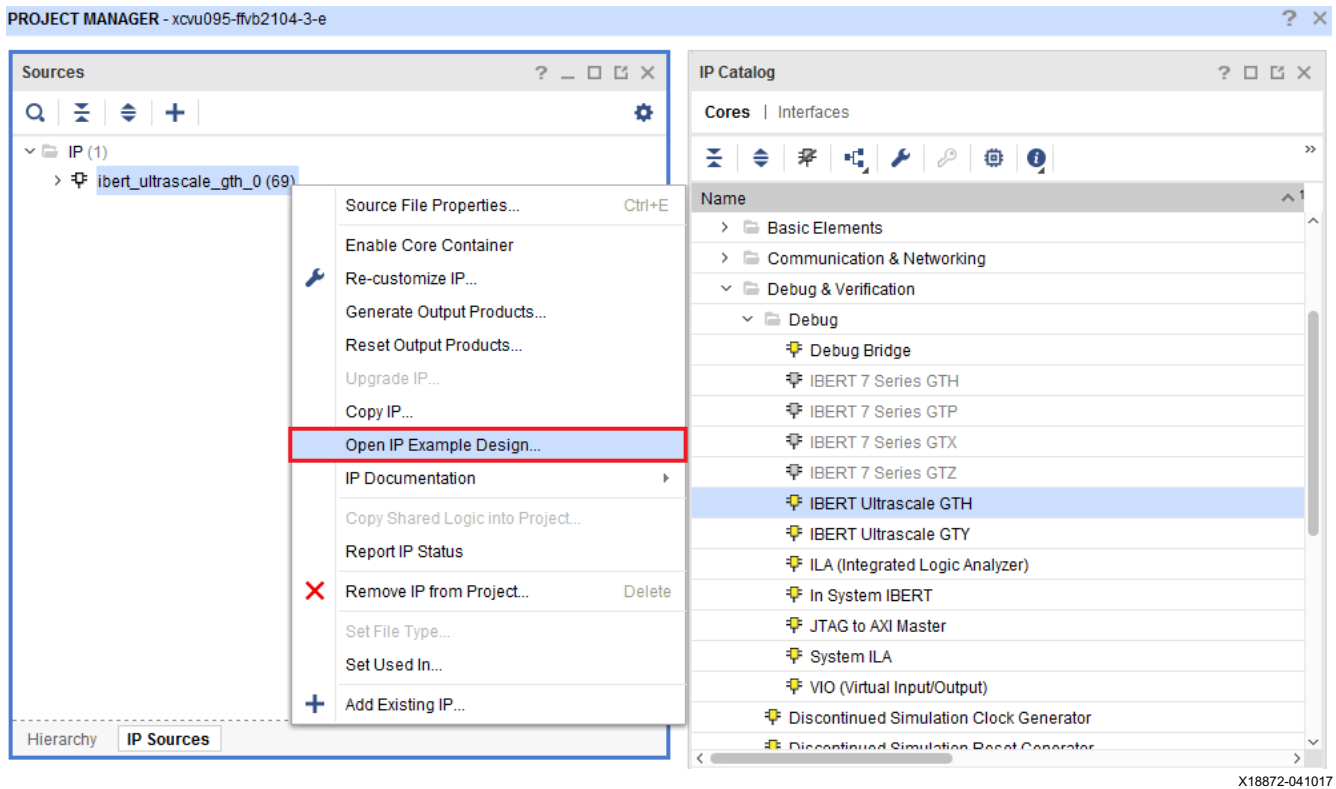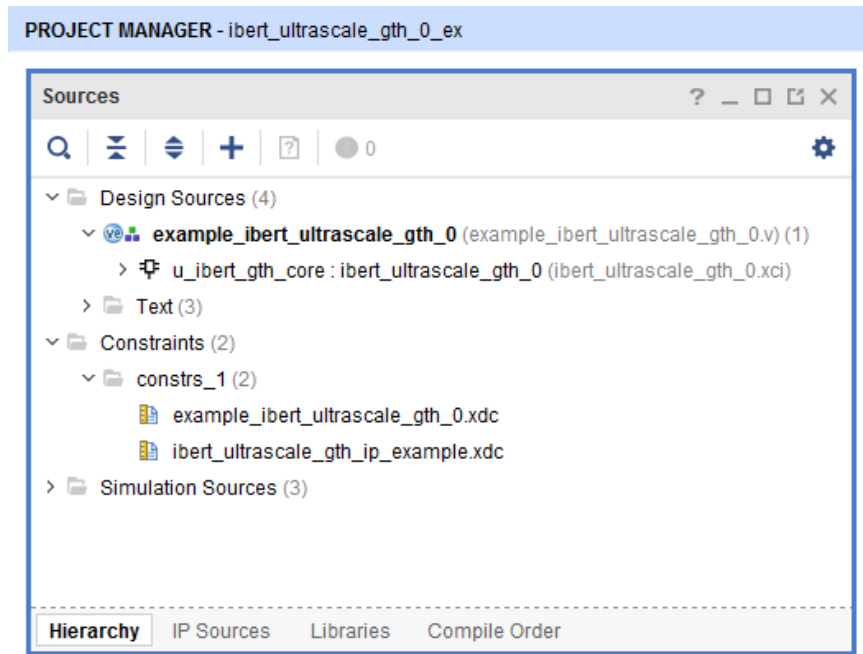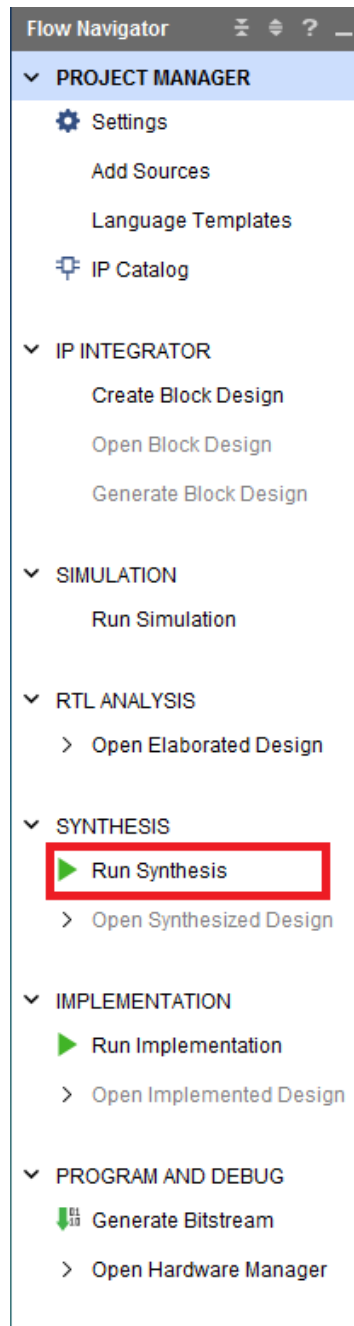

Figure 2-9: **Open IP Example Design**

11. From the Sources window, Design Sources should now show the IBERT design example (Figure 2-10).

X18873-041017
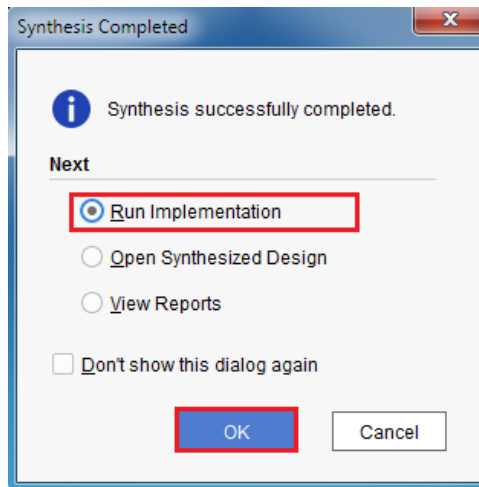
Figure 2-10: **Design Sources File Hierarchy**

Send Feedback

12. Click **Run Synthesis** from the Flow Navigator to synthesize the design (Figure 2-11).

X18874-041017
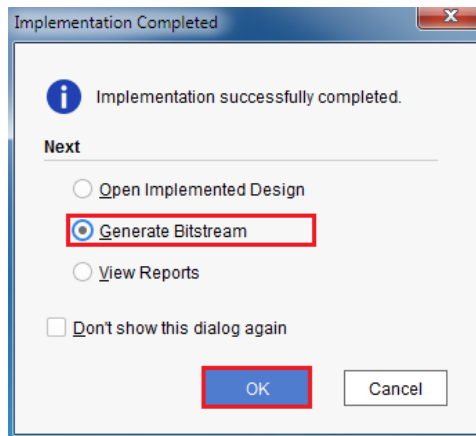
Figure 2-11: **Run Synthesis**

13. When the synthesis is done, a Synthesis Completed window opens. Select **Run Implementation** and click **OK** (Figure 2-12).

X18875-041017
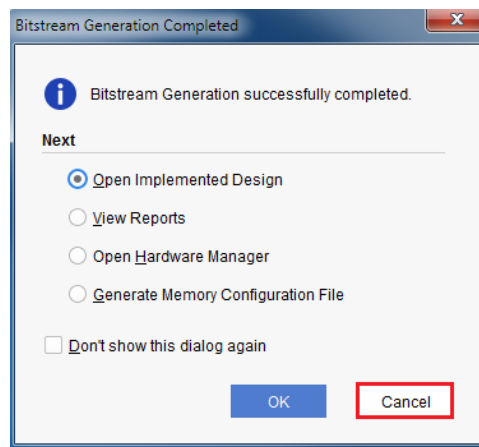
Figure 2-12: **Synthesis Completed**

14. When the implementation is done, an Implementation Completed window opens. Select **Generate Bitstream** and click **OK** (Figure 2-13).

X18876-041017

Figure 2-13: **Implementation Completed**

15. When the Bitstream Generation Completed dialog window appears, click **Cancel** (Figure 2-14).

X18877-041017

Figure 2-14: **Bitstream Generation Complete**

16. Navigate to the
    `...\ibert_ultrascale_gth_0_example\ibert_ultrascale_gth_0_exampl`
    `e.runs\impl_1` directory to locate the generated bitstream.

Send Feedback

Creating the GTY IBERT Core

The Vivado Design Suite 2017.4 is required to rebuild the designs shown here.

This section provides a procedure to create a single Quad GTY IBERT core. The procedure assumes Quad 124 at 28.00 Gb/s line rate, but cores for any of the GTY Quads with any supported line rate can be created following the same series of steps.

For more details on generating IBERT cores, see *Vivado Design Suite User Guide: Programming and Debugging* (UG908) [Ref 5].

1. Start the Vivado Design Suite.

2. In the Vivado Design Suite window, click **Manage IP** (highlighted in Figure 2-1) and select **New IP Location**.

3. In the Manage IP Settings window, click the **(...)** button next to the Part field to select the target part. Use the drop-down menus to filter the devices. Select the **xcvu095-ffvb2104-3-e** device (see Figure 2-2). Click **OK**.

4. Back on the Manage IP Catalog window, select **Verilog** for Target language, **Vivado Simulator** for Target simulator, **Mixed for Simulator language**, and a directory to save the customized IP (Figure 2-3). Click **Finish**.

   *Note:* Make sure the directory name does not include spaces.

5. In the IP Catalog window, expand the Debug & Verification folder, expand the Debug folder, and double-click **IBERT UltraScale GTY** (Figure 2-15).
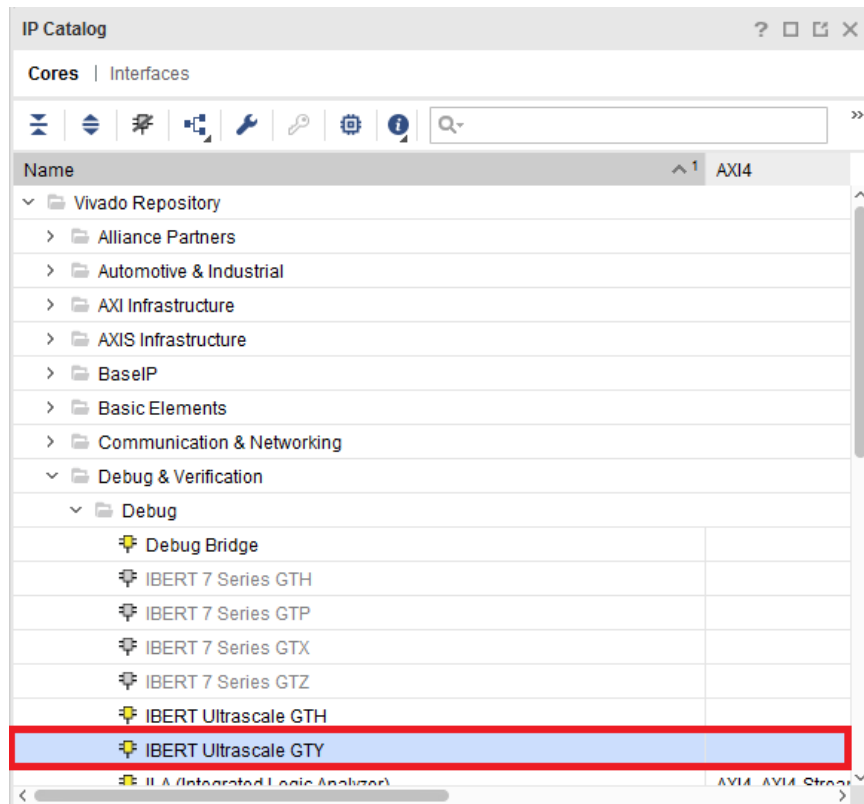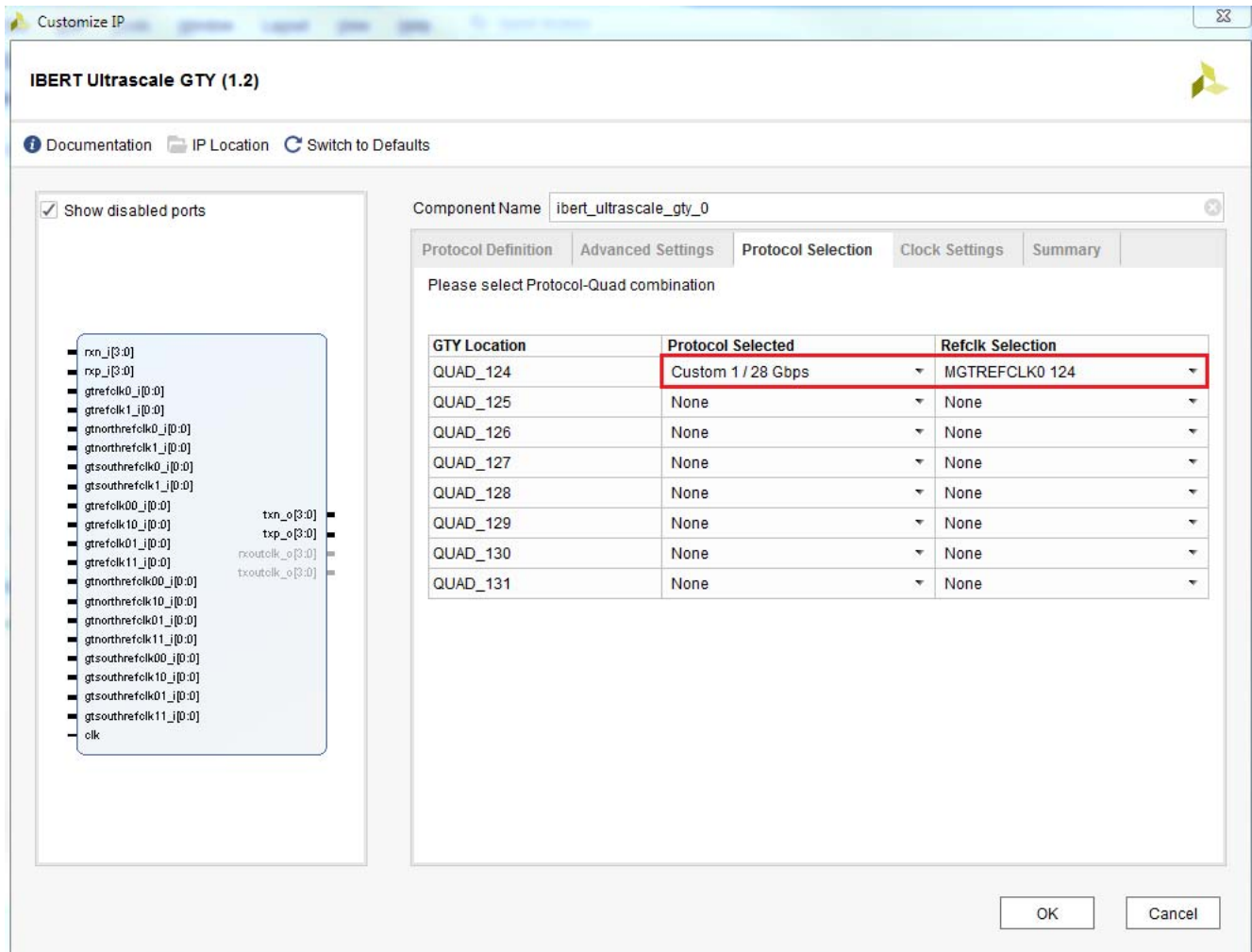

X18878-041017

Figure 2-15: **IP Catalog**

6. A Customize IP window opens. In the Protocol Definition tab, set the LineRate(Gb/s) to **28.00.** Change Refclk(MHz) to **125**. Keep defaults for the other fields (Figure 2-16).
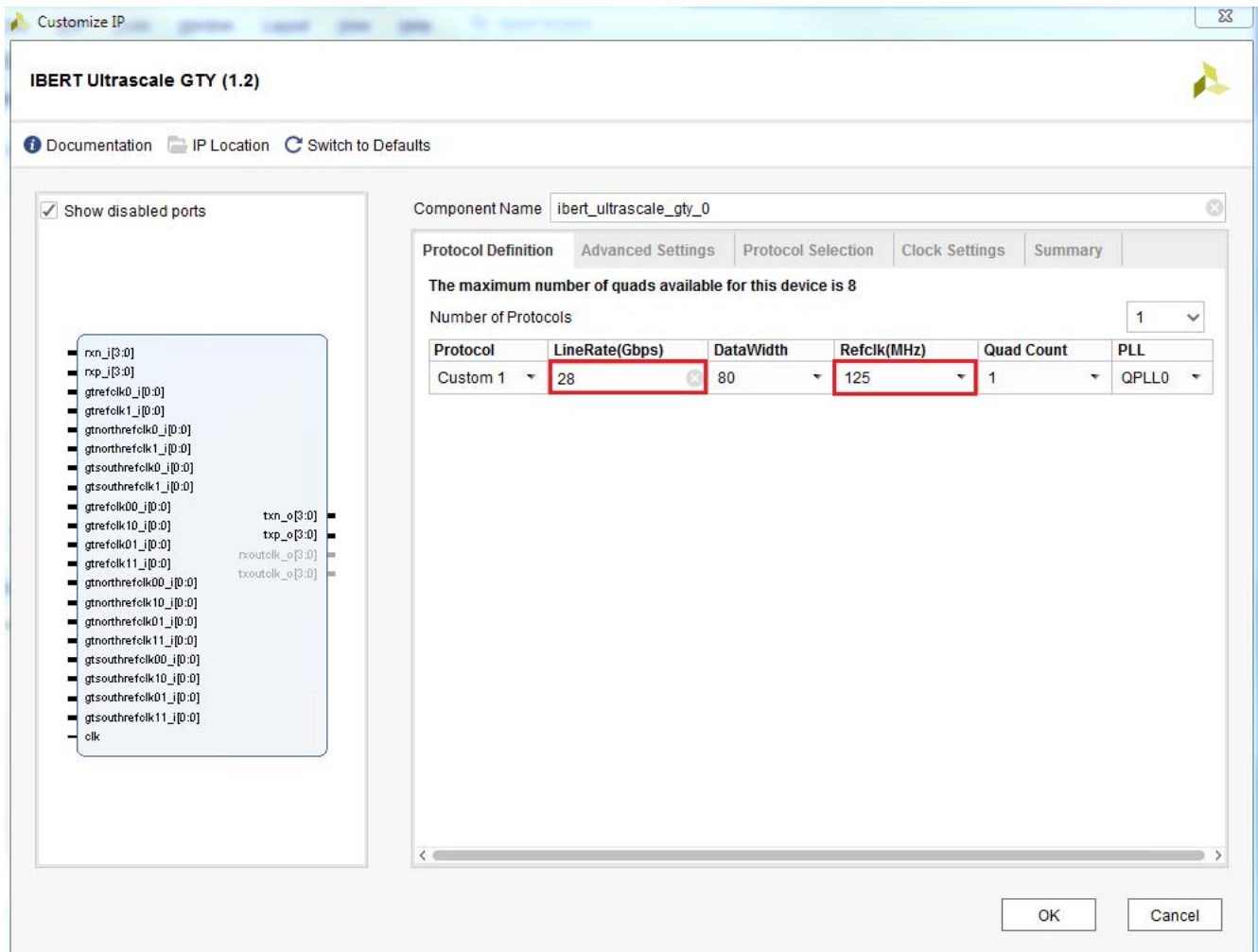
X18879-041017

Figure 2-16: **Customize IP — Protocol Definition**

7. In the Protocol Selection tab, use the Protocol Selected drop-down menu next to QUAD_124 to select **Custom 1 / 28.00 Gbps** and select **MGTREFCLK0 124** from the REFCLK Selection menu (Figure 2-17).

Figure 2-17: **Customize IP — Protocol Selection**

8. In the Clock Settings tab, select **DIFF SSTL15** for the I/O Standard, enter **AW14** for the P Package Pin (the FPGA pins where the system clock is connected), and make sure the Frequency (MHz) is set to **300** (Figure 2-18). Click **OK**.
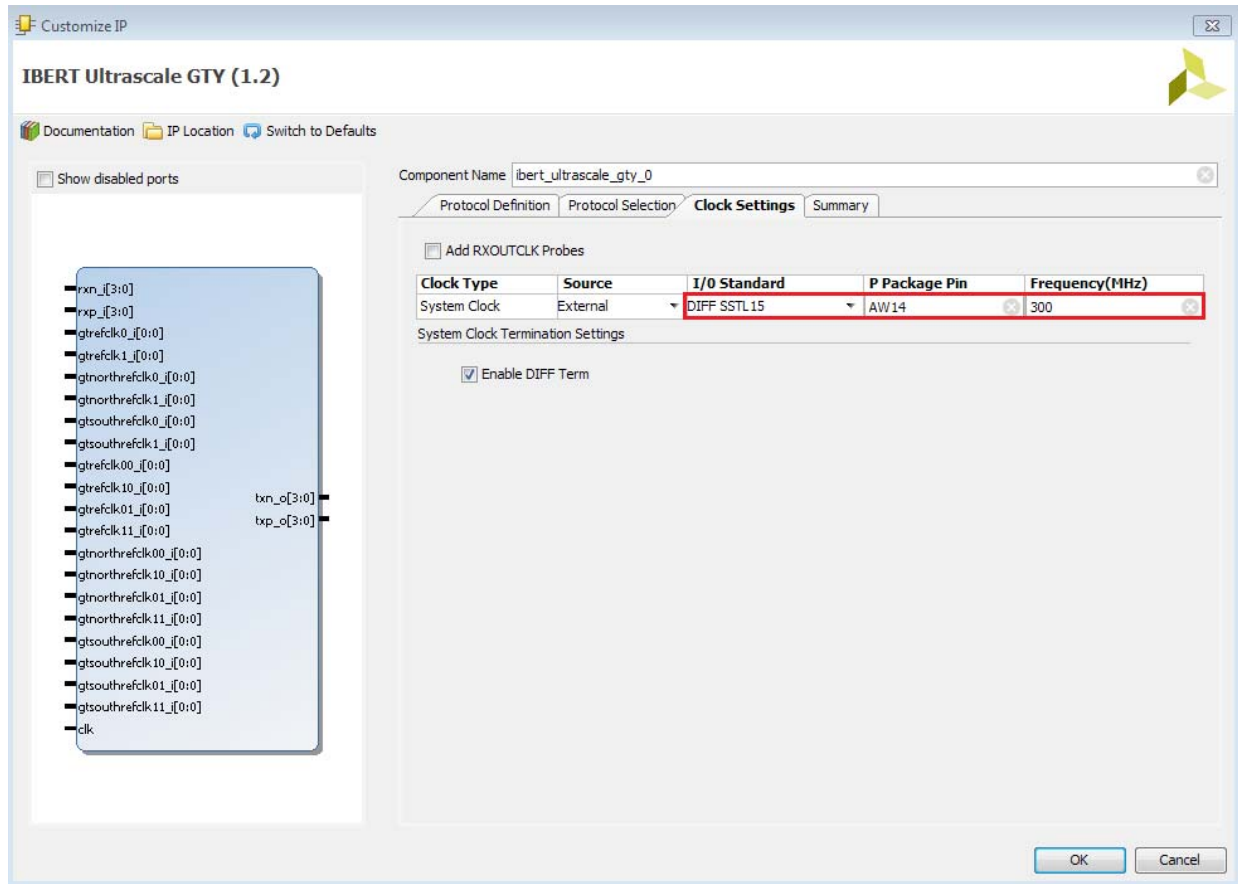
X15582-121416

Figure 2-18: **Customize IP — Clock Settings**

9. Select the **Global Synthesis** option and click **Generate** to generate the output product. (Figure 2-19).
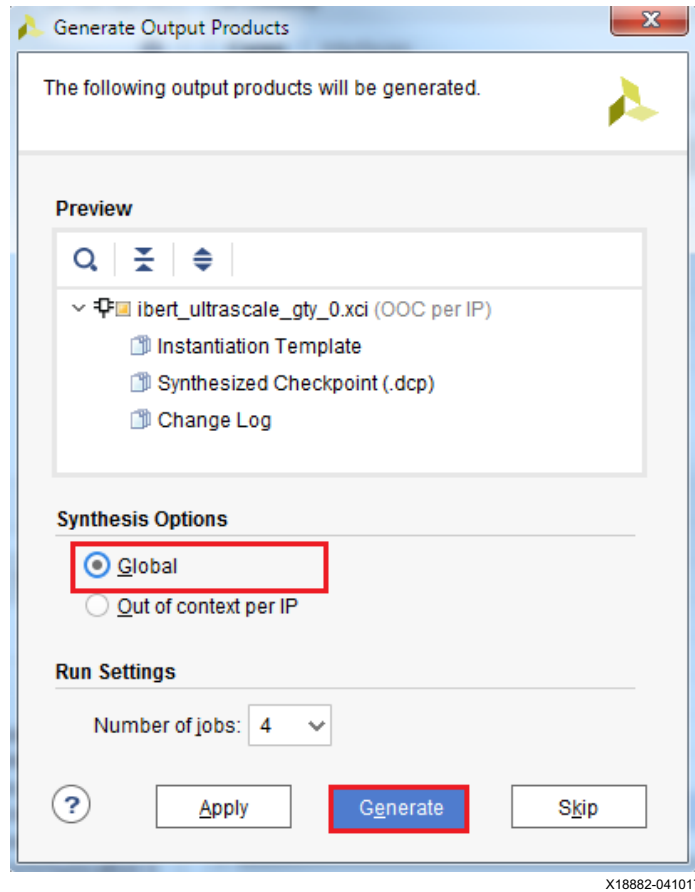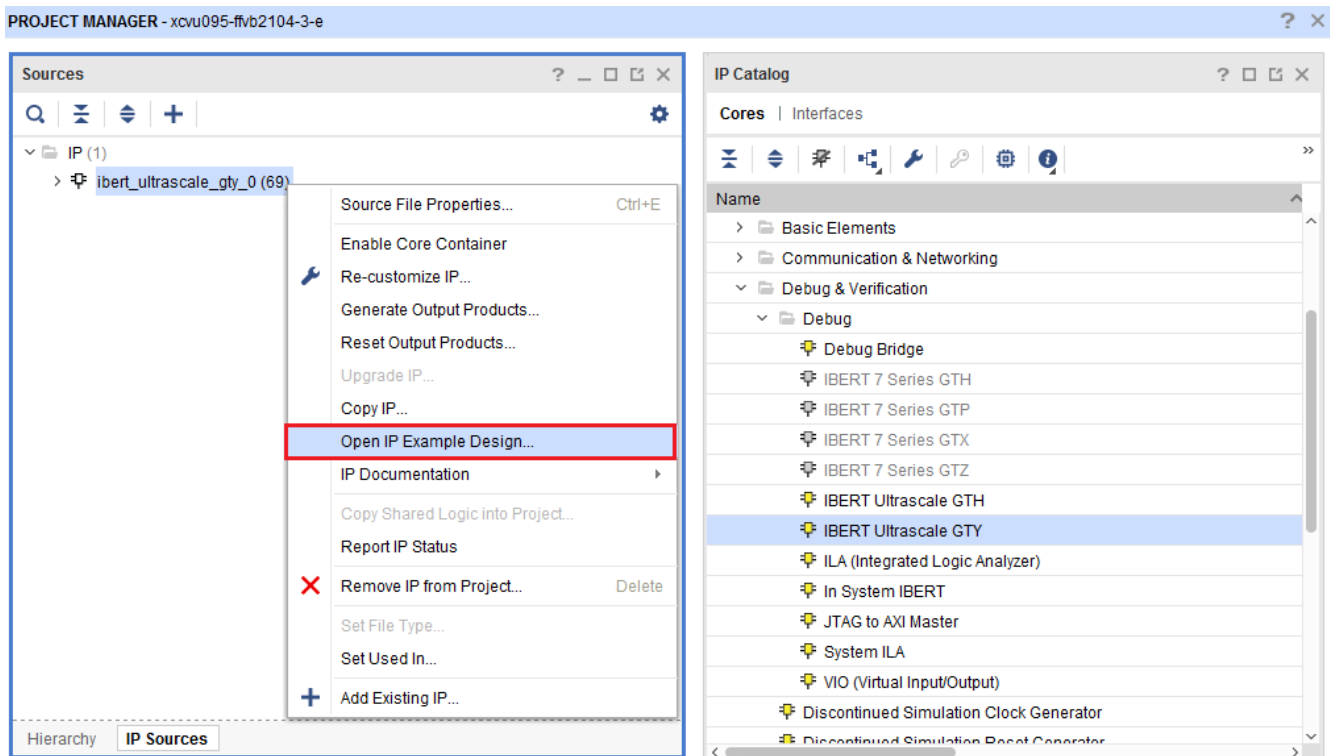

X18882-041017

Figure 2-19: **Generate Output Products**

10. From the Project Manager window, in the Sources window, right-click the **IBERT IP** and select **Open IP Example Design** (Figure 2-20). Specify a location to save the design, click **OK**. The example design launches in a new Vivado Design Suite window.

X18883-041017

Figure 2-20: **Open IP Example Design**

11. In the sources window, Design Sources should now show the IBERT design example (Figure 2-21).

X15585-121416
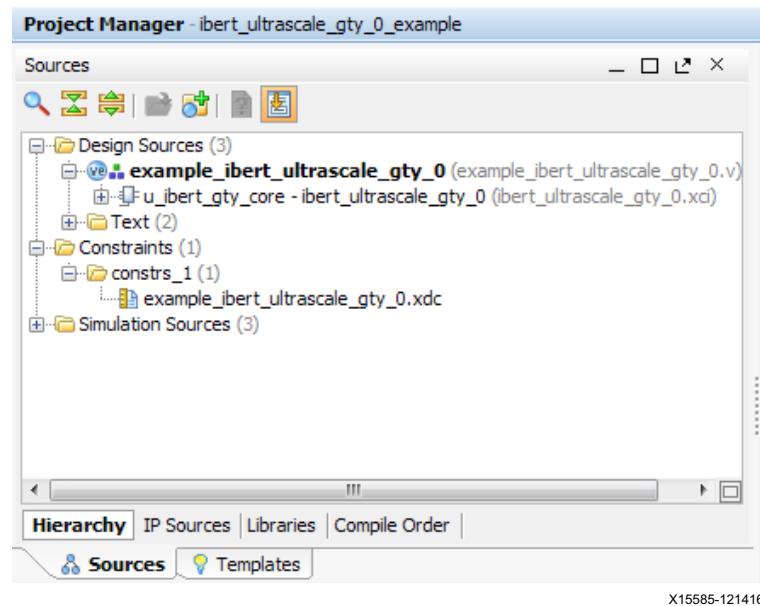
Figure 2-21: **Design Sources File Hierarchy**

12. Click **Run Synthesis** from the Flow Navigator to synthesize the design (Figure 2-11).

13. When the synthesis is done, a Synthesis Completed window opens. Select **Run Implementation** and click **OK** (Figure 2-12).

14. When the implementation is done, an Implementation Completed window opens. Select **Generate Bitstream** and click **OK** (Figure 2-13).

15. When the Bitstream Generation Completed dialog window appears, click **Cancel** (Figure 2-14).

16. Navigate to the `...\ibert_ultrascale_gty_0_example\ibert_ultrascale_gty_0_exampl e.runs\impl_1` directory to locate the generated bitstream.

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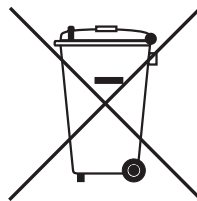
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- On Windows, select **Start > All Programs > Xilinx Design Tools > DocNav**.
- At the Linux command prompt, enter `docnav`.

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- In the Xilinx Documentation Navigator, click the **Design Hubs View** tab.
- On the Xilinx website, see the Design Hubs page.

Note: For more information on Documentation Navigator, see the Documentation Navigator page on the Xilinx website.

References

The most up to date information related to the VCU1287 kit and its documentation is available on these websites.

Virtex UltraScale FPGA VCU1287 Characterization Kit

Virtex UltraScale FPGA VCU1287 Characterization Kit documentation

Virtex UltraScale FPGA VCU1287 Characterization Kit Master Answer Record (AR 66056)

These documents provide supplemental material useful with this guide:

1. *VCU1287 Characterization Board User Guide* (UG1121)

2. *HW-CLK-101-SCLK2 SuperClock-2 Module User Guide* (UG770)

3. *Silicon Labs CP210x USB-to-UART Installation Guide* (UG1033)

4. *UltraScale Architecture Configuration User Guide* (UG570)

5. *Vivado Design Suite User Guide: Programming and Debugging (*UG908)

6. *Kintex UltraScale FPGAs Data Sheet: DC and AC Switching Characteristics* (DS892)

7. *Integrated Bit Error Ratio Tester 7 Series GTX Transceivers: LogiCORE IP Product Guide* (PG132)

8. *Virtex UltraScale FPGAs Data Sheet: DC and AC Switching Characteristics* (DS893)

9. *Zynq-7000 All Programmable SoC Overview* (DS190)

10. *UltraScale Architecture GTH Transceivers User Guide* (UG576)

11. *Vivado Design Suite User Guide: Getting Started* (UG910)

12. *Tera Term Terminal Emulator Installation Guide* (UG1036)

13. *UltraScale FPGAs Transceivers Wizard LogiCORE IP Product Guide* (PG182)

Training Resources

14. Vivado Design Suite Hands-on Introductory Workshop

15. Vivado Design Suite Tool Flow

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