

USER MANUAL



Copyright © Terasic Inc. All Rights Reserved.

TABLE OF CONTENTS

Chapter 1	Introduction	2
1.1	Features	2
1.2	The Package Contents	3
1.3	Assemble XTS-FMC with FPGA Main board	4
1.4	Getting Help.....	5
Chapter 2	Board Specification	6
2.1	Layout and Components	6
2.2	Block Diagram.....	7
2.3	Mechanical Specifications	9
Chapter 3	Board Components	10
3.1	FMC Expansion Connector.....	10
3.2	Programmable Clock Generator.....	14
Chapter 4	Demonstrations	15
4.1	XTS-FMC Loopback on the TR5	15
4.2	XTS-FMC Loopback on the Han Pilot Platform	19
4.3	XTS-FMC SuperLite Loopback on the Han Pilot Platform.....	21
Appendix	24	
	Revision History	24

Chapter 1

Introduction

The XTS-FMC daughter card is designed to convert FPGA transceiver channels to SMA connectors through a FPGA Mezzanine Card(FMC) interface. It is intended to allow users to evaluate the performance of transceiver-based host boards with FMC interface specifically the Stratix, Arria and Cyclone FPGA with integrated transceivers. Through the SMA connectors, the FPGA transceiver signals can be easily connected to measurement instruments as well as allowing gigabit data rate communication between multiple FPGA boards. In addition, there is a clock generator (CDCM6208) that can output the various reference clock for different applications to the transceiver bank of the FPGA through the FMC connector.

The XTS-FMC daughter card is the ideal platform to allow users to prototype and test their high-speed interfaces quickly and easily in support of transceiver performance for jitter, protocol compliance, and equalization.

1.1 Features

Figure 1-1 shows the photo of the XTS-FMC card. The important functions of the XTS-FMC card are listed below:

- Convert FPGA transceiver channels to SMA connectors through FMC connector
- Support maximum 4 transceiver channels (Depend on the FPGA host board)
- SMA connectors for external clock input
- Programmable clock generator for reference clock input

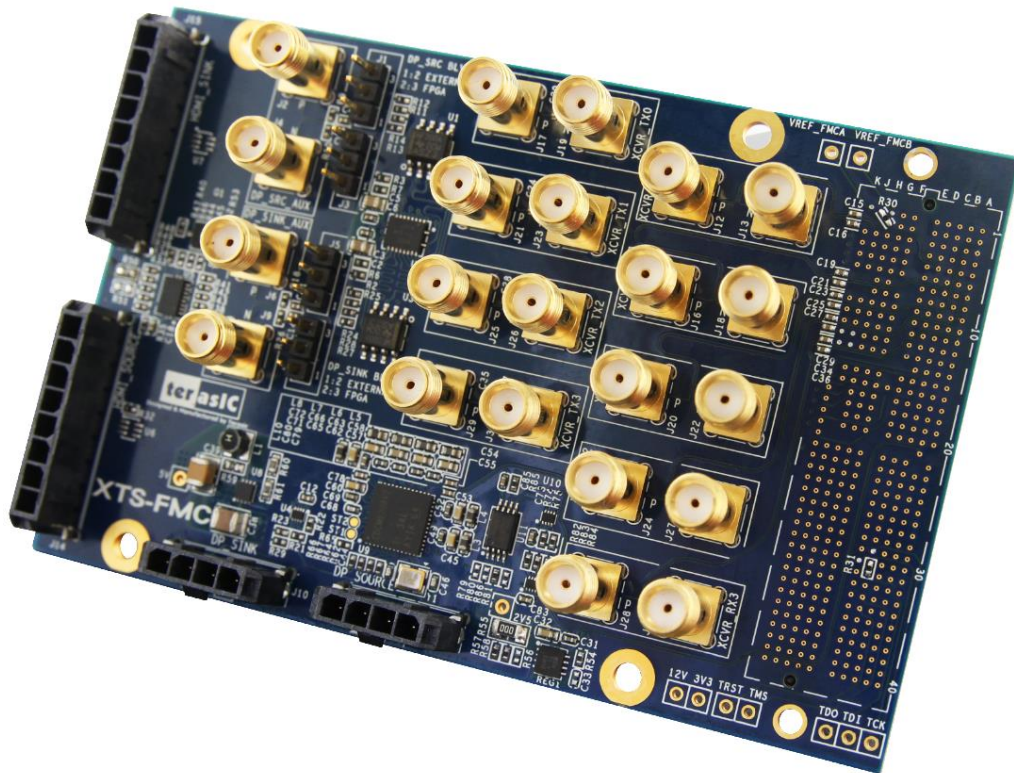


Figure 1-1 The XTS-FMC Card.

1.2 The Package Contents

The XTS-FMC kit comes with the following items (see [Figure 1-2](#)):

1. XTS-FMC Daughter Card
2. Screw & Copper Pillar Package
3. CD Download Guide

The system CD contains technical documents of the XTS-FMC card, which include component datasheets, demonstrations, schematic and user manual. Users can download the CD from the link below:

<http://xts-fmc.terasic.com/cd>

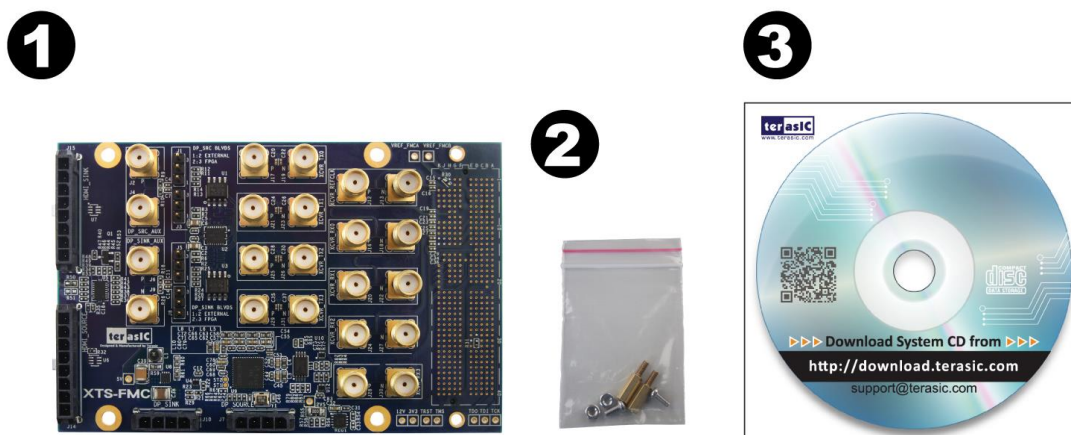


Figure 1-2 The contents of the XTS-FMC card.

1.3 Assemble XTS-FMC with FPGA Main board

In order to make the XTS-FMC daughter card and the FMC connector on the FMC card with more secure hookup, the FMC side of the XTS-FMC daughter card has reserved two screw holes, as shown in **Figure 1-3**. Users can use the screws, copper pillars, and nuts that come with the XTS-FMC, to secure the XTS-FMC on the FPGA main board, as shown in **Figure 1-4**. Because transceiver is mostly used for high-speed transmission applications, **we strongly recommend** that users use the screws to secure the connection between the FPGA main board and the XTS-FMC card.



Figure 1-3 The two screw holes on XTS-FMC card.

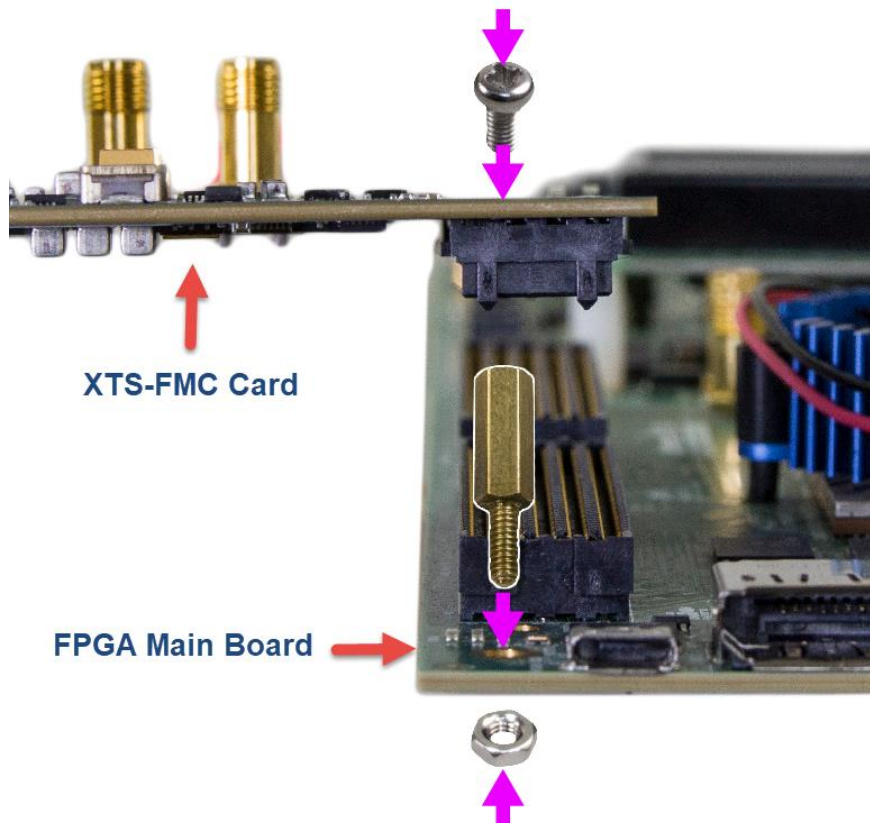


Figure 1-4 Secure the XTS-FMC on the FPGA main board

1.4 Getting Help

Here are the addresses where you can get help if you encounter any problems:

Terasic Technologies

9F., No.176, Sec.2, Gongdao 5th Rd, East Dist, Hsinchu City, 30070. Taiwan

Email: support@terasic.com

Tel.: +886-3-575-0880

Website: xts-fmc.terasic.com

Chapter 2

Board Specification

This chapter describes the architecture of the XTS card including block diagram and components.

2.1 Layout and Components

The picture of the XTS-FMC card is shown in **Figure 2-1** and **Figure 2-2**. It depicts the layout of the board and indicates the locations of the connectors and key components.

Note: The interface labeled with the blue block in **Figure 2-1** is the reserve interface and can be ignored.

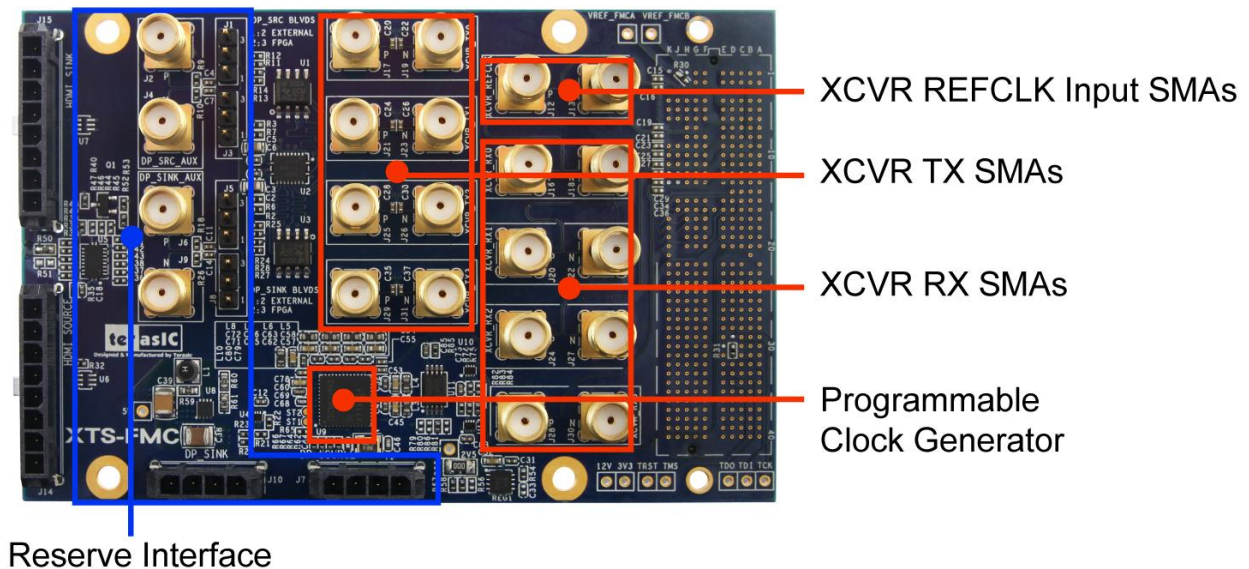


Figure 2-1 Mechanical Layout of the XTS-FMC card

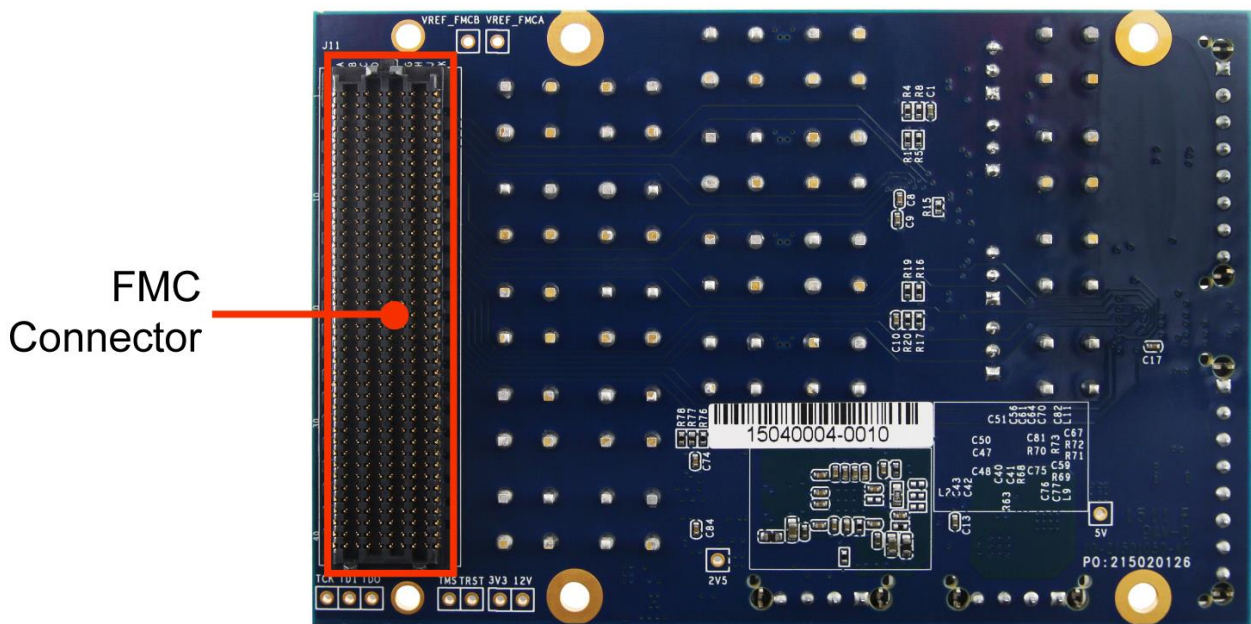


Figure 2-2 Mechanical Layout of the XTS-FMC card

The following components are provided on the XTS-FMC card:

- FMC expansion connector (J11)
- TX SMAs (J17/J19,J21/J23,J25/J26,J29/J31)
- RX SMAs (J16/J18,J20/J22,J24/J27,J28/J30)
- XCVR reference input SMAs (J12/J13)

2.2 Block Diagram

Figure 2-3 is the block diagram of the XTS-FMC card.

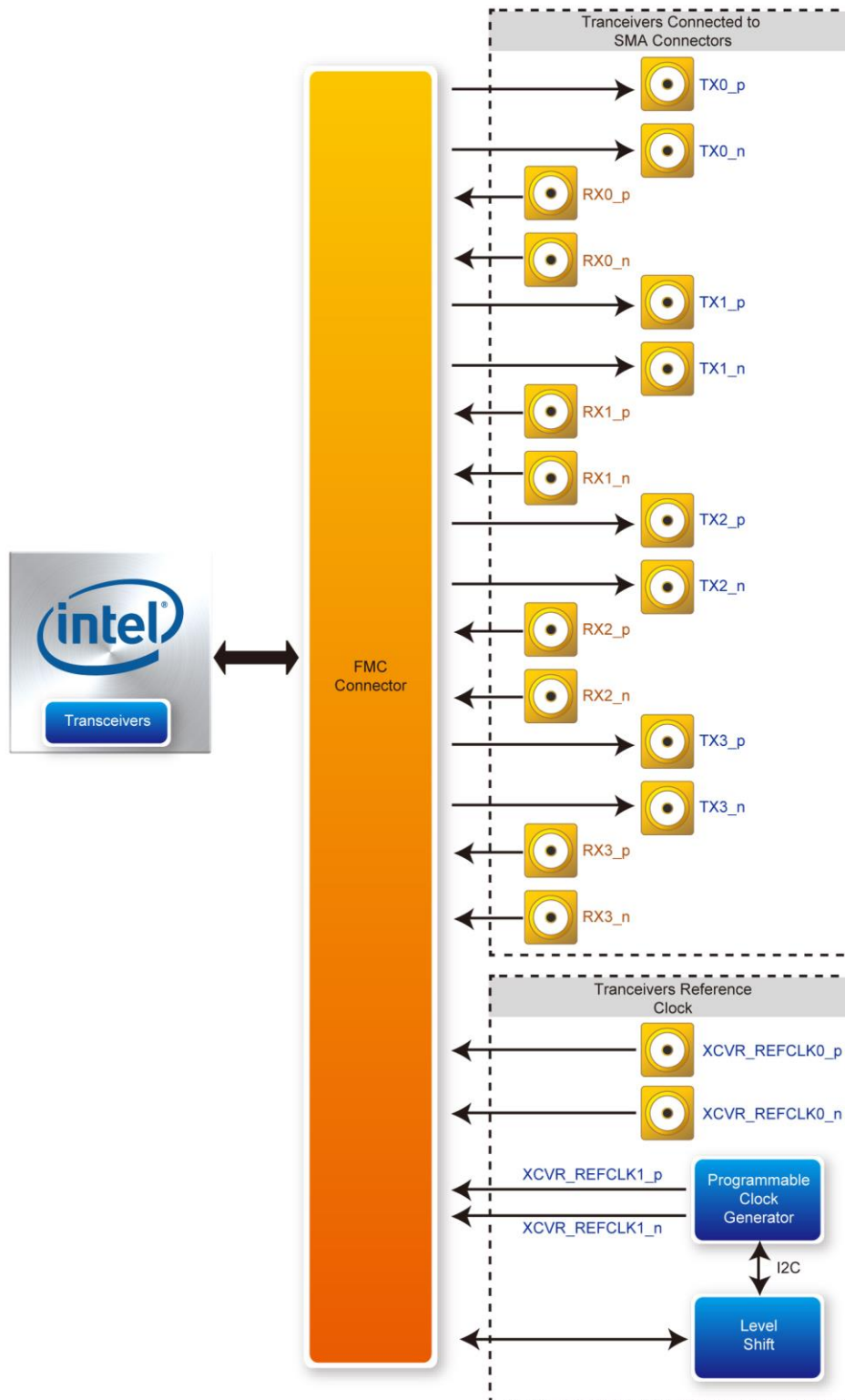


Figure 2-3 Block diagram of the XTS-FMC card

2.3 Mechanical Specifications

Figure 2-3 is the mechanical layout of the XTS-FMC board.

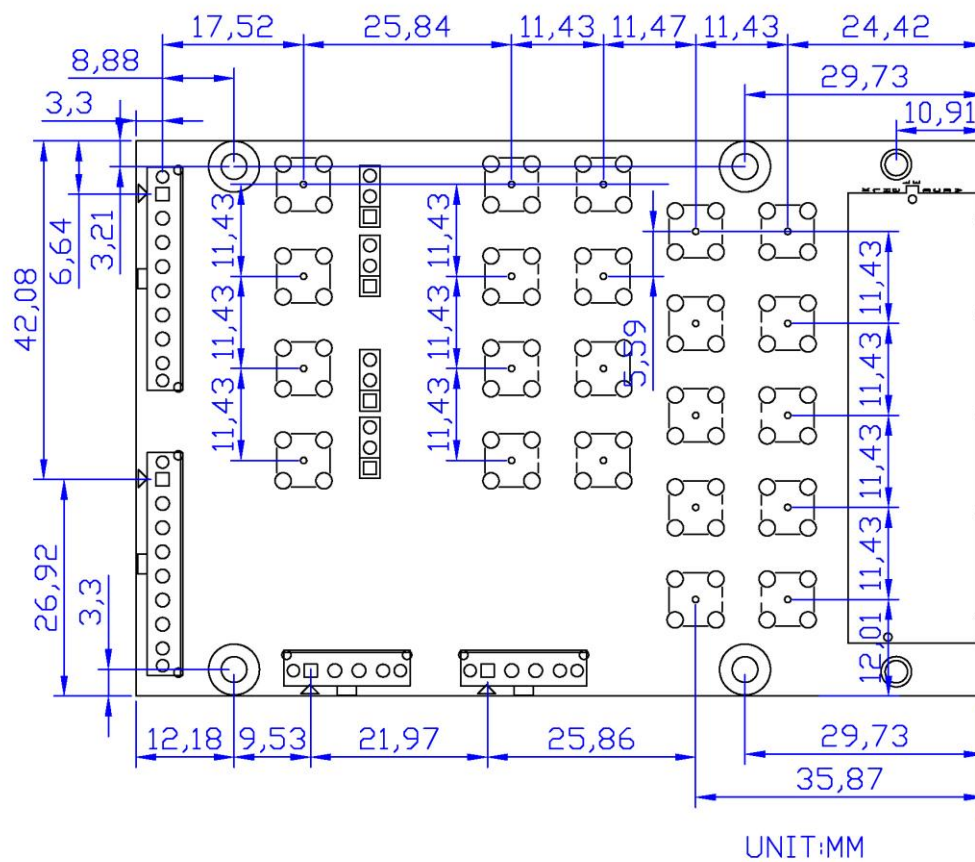
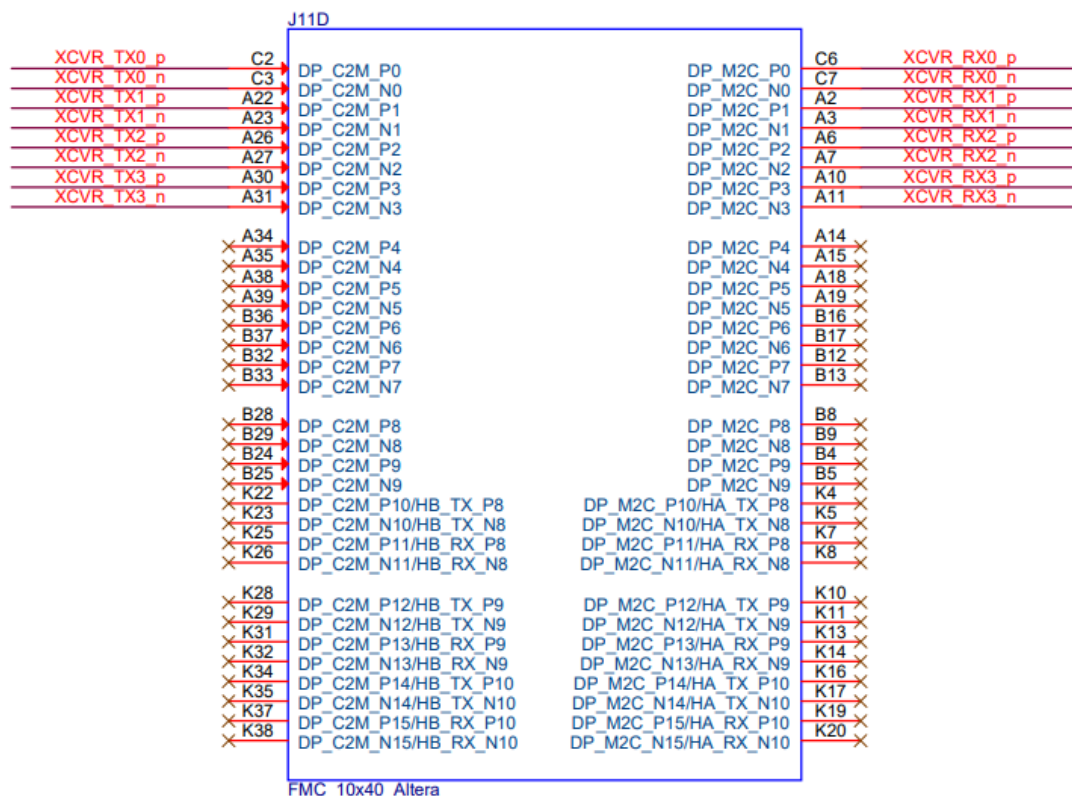


Figure 2-4 The mechanical layout of the XTS-FMC card



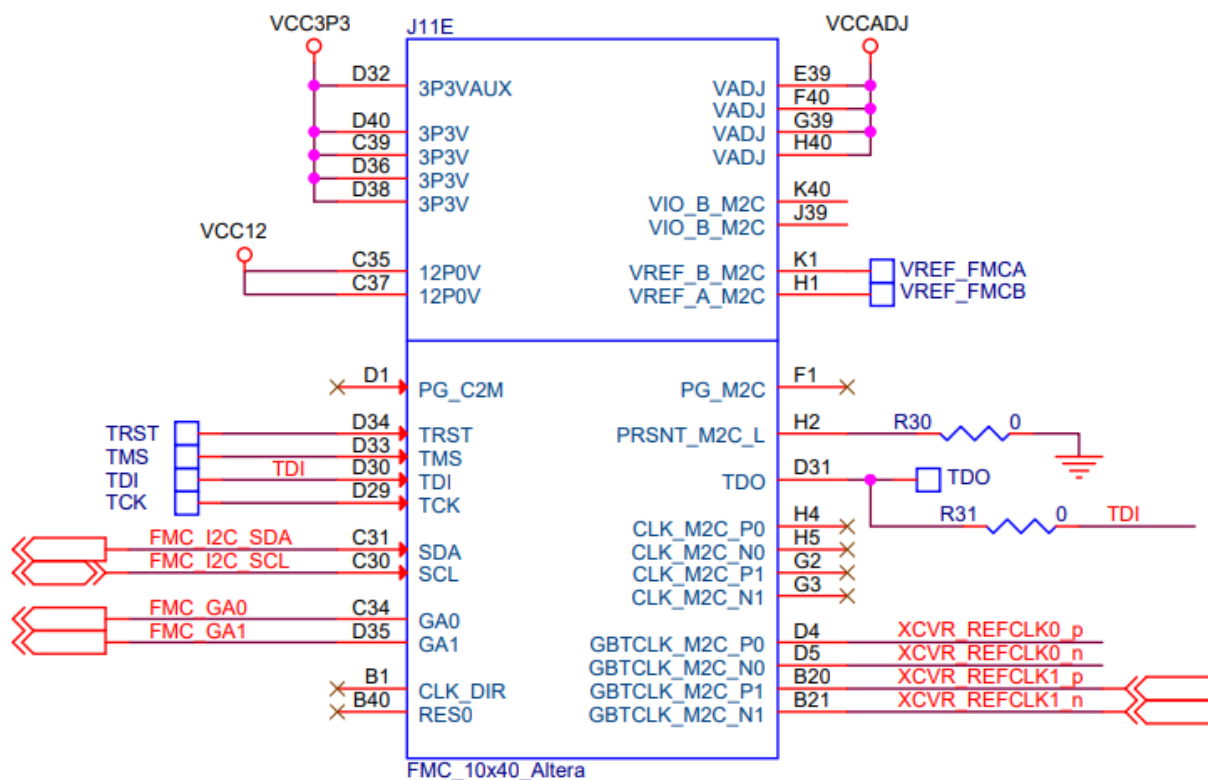


Figure 3-2 Signal names of XTS-FMC connector part 2

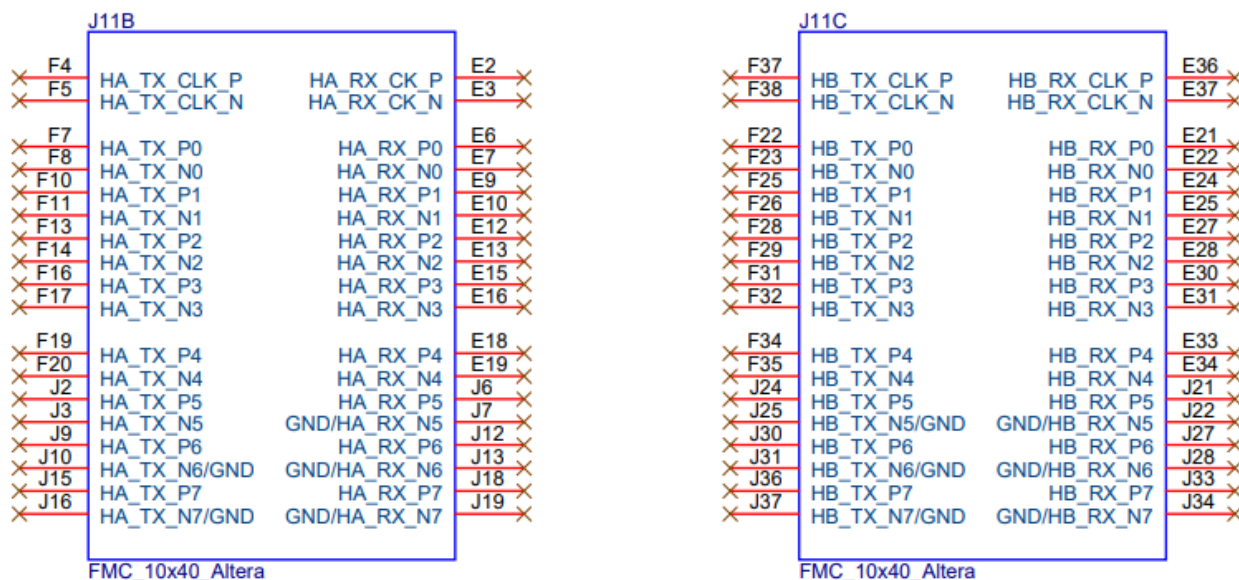


Figure 3-3 Signal names of XTS-FMC connector part 3

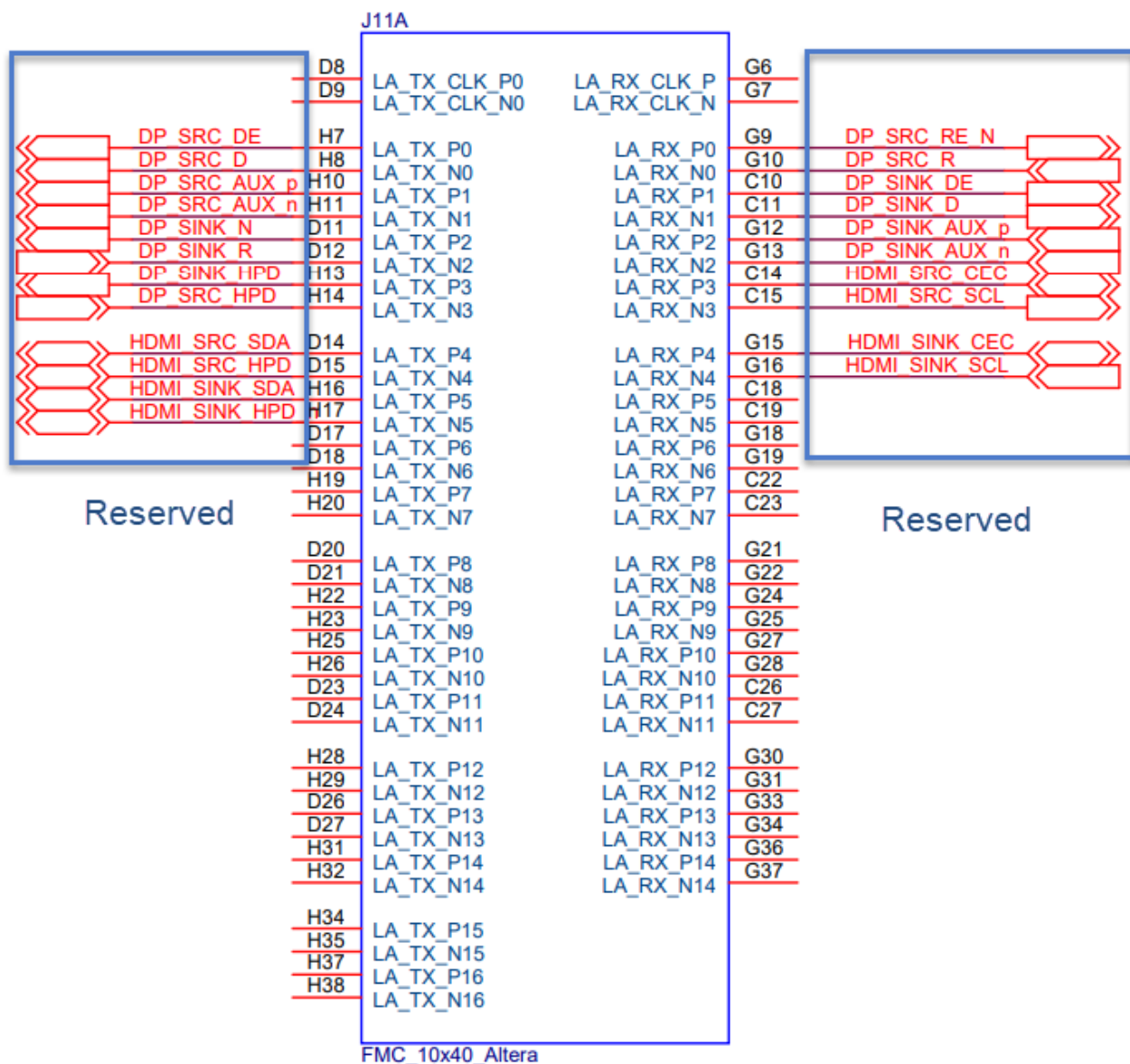


Figure 3-4 Signal names of XTS-FMC connector part 4

Table 3-1 FMC Pin Assignments

Signal Name	FMC Pin No.	Direction	I/O Standard	Description
XCVR_TX0_p	PIN_C2	Output	1.4-V PCML	SMA Transceiver Output Port0, connected to J17(SMA)
XCVR_TX0_n	PIN_C3	Output	1.4-V PCML	SMA Transceiver Output Port0, connected to J19(SMA)
XCVR_TX1_p	PIN_A22	Output	1.4-V PCML	SMA Transceiver Output Port1, connected to J21(SMA)
XCVR_TX1_n	PIN_A23	Output	1.4-V PCML	SMA Transceiver Output Port1, connected to J23(SMA)

XCVR_TX2_p	PIN_A26	Output	1.4-V PCML	SMA Transceiver Output Port2, connected to J25(SMA)
XCVR_TX2_n	PIN_A27	Output	1.4-V PCML	SMA Transceiver Output Port2, connected to J26(SMA)
XCVR_TX3_p	PIN_A30	Output	1.4-V PCML	SMA Transceiver Output Port3, connected to J29(SMA)
XCVR_TX3_n	PIN_A31	Output	1.4-V PCML	SMA Transceiver Output Port3, connected to J31(SMA)
XCVR_RX0_p	PIN_C6	Input	1.4-V PCML	SMA Transceiver Input Port0, connected to J16(SMA)
XCVR_RX0_n	PIN_C7	Input	1.4-V PCML	SMA Transceiver Input Port0, connected to J18(SMA)
XCVR_RX1_p	PIN_A2	Input	1.4-V PCML	SMA Transceiver Input Port1, connected to J20(SMA)
XCVR_RX1_n	PIN_A3	Input	1.4-V PCML	SMA Transceiver Input Port1, connected to J22(SMA)
XCVR_RX2_p	PIN_A6	Input	1.4-V PCML	SMA Transceiver Input Port2, connected to J24(SMA)
XCVR_RX2_n	PIN_A7	Input	1.4-V PCML	SMA Transceiver Input Port2, connected to J27(SMA)
XCVR_RX3_p	PIN_A10	Input	1.4-V PCML	SMA Transceiver Input Port3, connected to J28(SMA)
XCVR_RX3_n	PIN_A11	Input	1.4-V PCML	SMA Transceiver Input Port3, connected to J30(SMA)
XCVR_REFCLK0_p	PIN_D4	Input	LVDS	External reference clock input, connected to J12(SMA)
XCVR_REFCLK0_n	PIN_D5	Input	LVDS	External reference clock input, connected to J13(SMA)
XCVR_REFCLK1_p	PIN_B20	Input	LVDS	External reference clock input, connected to the clock generator CDCM6208.
XCVR_REFCLK1_n	PIN_B21	Input	LVDS	External reference clock input, connected to the clock generator CDCM6208.
FMC_I2C_SDA	PIN_C31	Inout	VCCADJ	I2C data bus for the clock generator CDCM6208
FMC_I2C_SCL	PIN_C30	Ouput	VCCADJ	I2C clock bus for the clock generator CDCM6208

3.2 Programmable Clock Generator

The XTS-FMC card provides a programmable clock generator: CDCM6208. This clock generator provides a variety of frequencies which can have different formats to the FPGA's transceiver bank for different applications as reference clock. The user can modify the output frequency of DMC6208 from the FPGA through the I2C interface. The I2C address of this device is 7'b1010100.

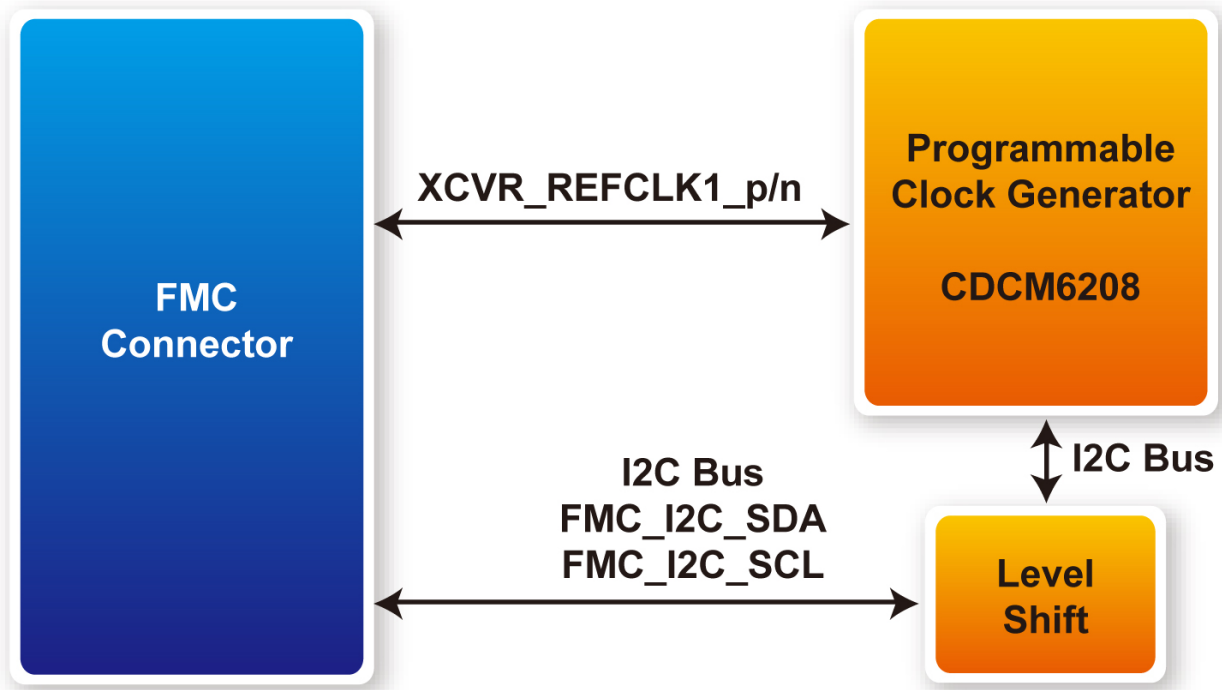


Figure 3-5 Block diagram of the FMC connector and the CDCM208

Chapter 4

Demonstrations

This chapter illustrates the transceiver loopback reference design for the XTS-FMC card.

4.1 XTS-FMC Loopback on the TR5

The transceiver test code is used to verify 4 transceiver channels of the FMC connector through the XTS-FMC card and SMA cables. The transceiver channels are verified with PRBS31 test pattern and with the data rates. For 5SGXEA7N2F45C2 Device of the TR5 board, the data rate of the transceiver channel on the FMC connector runs at 12.5G bps.

■ Required Equipments

To enable an external loopback of transceiver channels, the following fixtures are required:

- TR5 board and XTS-FMC card.
- 8 SMA cables for loopback the TX and RX port on the XTS-FMC card.

■ Demonstration Setups

The transceiver test code is available in the folder System CD\Demonstrations\TR5\demo_batch. Here are the procedures to perform transceiver channel test:

1. Use the SMA cables to connect the TX ports and the RX ports on the XTS-FMC card to implement the loopback function (See **Figure 4-1**, **Figure 4-2**). There are four channels in total, note the difference between positive and negative ports.

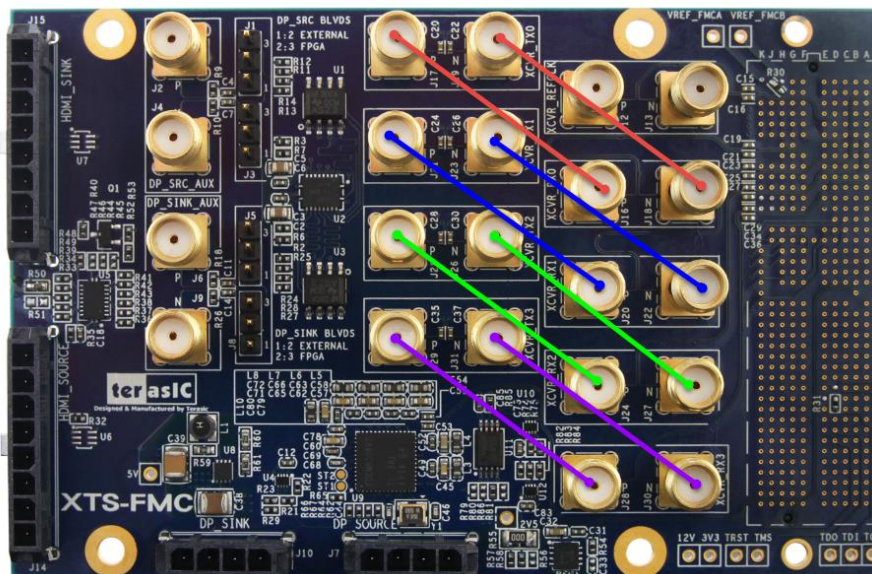


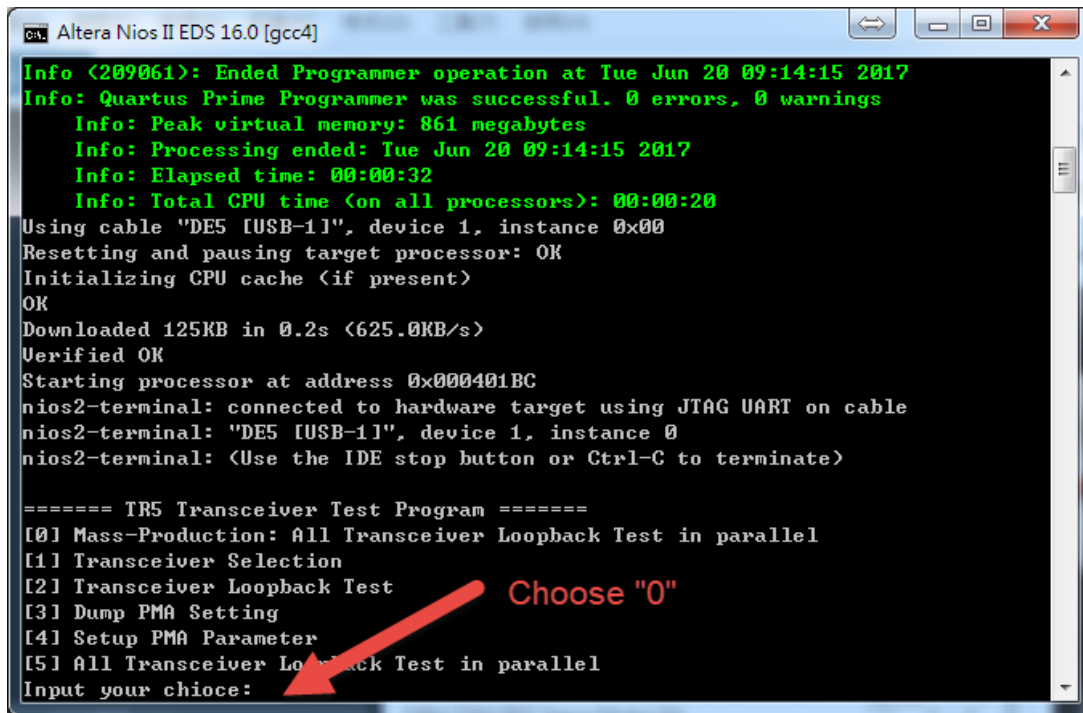
Figure 4-1 SMA loopback setup

2. Connect the XTS-FMC card to the FMC D or FMC A connector of the TR5 board. Make sure the FMC connector between the two boards is locked with copper posts and screws (See section 1.3).



Figure 4-2 The Connections between the XTS-FMC card and TR5 board

3. Connect your TR5 board to your PC with a mini USB cable.
4. Connect Power to the TR5 board.
5. Copy the demo_batch folder (from System CD) to your local disk.
6. Power on the TR5 board.
7. Execute 'test.bat' in the demo_batch folder under your local disk.
8. The batch file will download .sof and .elf files, and start the test. The Nios-Terminal as shown in Figure 4-3 will appear and choose "0" to test all the transceiver loopback test.

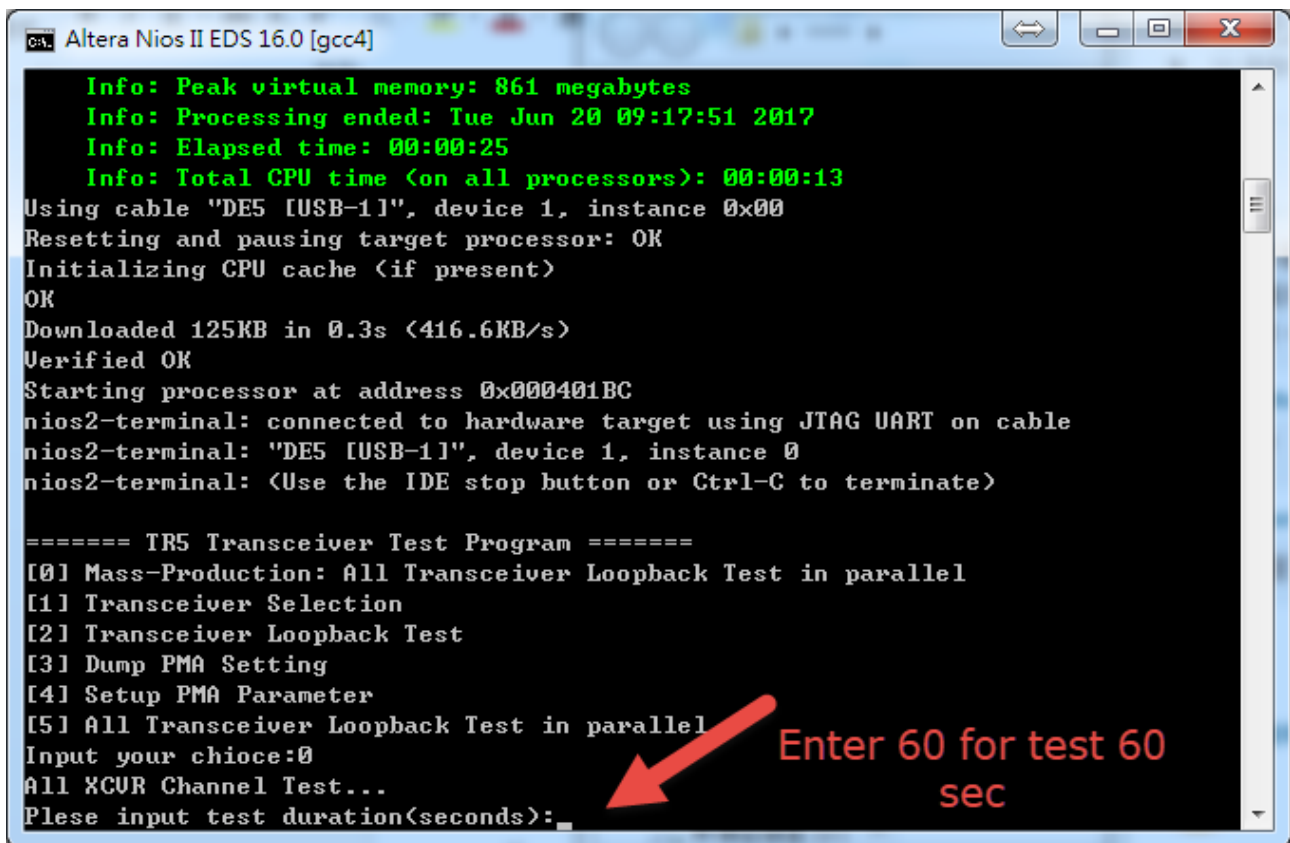


```
Altera Nios II EDS 16.0 [gcc4]
Info <2099061>: Ended Programmer operation at Tue Jun 20 09:14:15 2017
Info: Quartus Prime Programmer was successful. 0 errors, 0 warnings
Info: Peak virtual memory: 861 megabytes
Info: Processing ended: Tue Jun 20 09:14:15 2017
Info: Elapsed time: 00:00:32
Info: Total CPU time <on all processors>: 00:00:20
Using cable "DE5 [USB-1]", device 1, instance 0x00
Resetting and pausing target processor: OK
Initializing CPU cache <if present>
OK
Downloaded 125KB in 0.2s <625.0KB/s>
Verified OK
Starting processor at address 0x000401BC
nios2-terminal: connected to hardware target using JTAG UART on cable
nios2-terminal: "DE5 [USB-1]", device 1, instance 0
nios2-terminal: <Use the IDE stop button or Ctrl-C to terminate>

===== TR5 Transceiver Test Program =====
[0] Mass-Production: All Transceiver Loopback Test in parallel
[1] Transceiver Selection
[2] Transceiver Loopback Test
[3] Dump PMA Setting
[4] Setup PMA Parameter
[5] All Transceiver Loopback Test in parallel
Input your choice:
```

Figure 4-3 Choose the Test function

9. Then enter how many seconds you want to test the transmission (See [Figure 4-4](#)). For example, enter “60” for test 60 second.



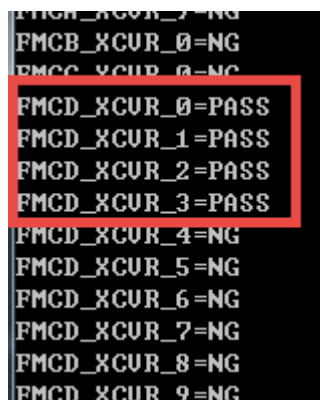
```
Altera Nios II EDS 16.0 [gcc4]

Info: Peak virtual memory: 861 megabytes
Info: Processing ended: Tue Jun 20 09:17:51 2017
Info: Elapsed time: 00:00:25
Info: Total CPU time (on all processors): 00:00:13
Using cable "DE5 [USB-1]", device 1, instance 0x00
Resetting and pausing target processor: OK
Initializing CPU cache (if present)
OK
Downloaded 125KB in 0.3s (416.6KB/s)
Verified OK
Starting processor at address 0x000401BC
nios2-terminal: connected to hardware target using JTAG UART on cable
nios2-terminal: "DE5 [USB-1]", device 1, instance 0
nios2-terminal: <Use the IDE stop button or Ctrl-C to terminate>

===== TR5 Transceiver Test Program =====
[0] Mass-Production: All Transceiver Loopback Test in parallel
[1] Transceiver Selection
[2] Transceiver Loopback Test
[3] Dump PMA Setting
[4] Setup PMA Parameter
[5] All Transceiver Loopback Test in parallel
Input your chioce:0
All XCVR Channel Test...
Plese input test duration(seconds):
```

Figure 4-4 Choose test duration

10. The test result will be displayed after the test time has elapsed (See [Figure 4-5](#)). It should be noted that this test code will test all the transceivers of the FMC A and FMC D connectors on the TR5 board (8 pairs of transceivers for each connector). Since XTS-FMC card can only test 4 pairs of transceivers. So the test result will only show the first four transceivers (0~3) of FMC A or FMC D are PASS or NG. Other transceiver test results can be ignored.



```
FMCD_XCUR_0=PASS
FMCD_XCUR_1=PASS
FMCD_XCUR_2=PASS
FMCD_XCUR_3=PASS
FMCD_XCUR_4=NG
FMCD_XCUR_5=NG
FMCD_XCUR_6=NG
FMCD_XCUR_7=NG
FMCD_XCUR_8=NG
FMCD_XCUR_9=NG
```

Figure 4-5 The test result of the transceiver loopback

4.2 XTS-FMC Loopback on the Han Pilot Platform

This section describes the use of the XTS-FMC card to test the FPGA's transceiver loopback on the HAN pilot platform. The basic operation is roughly the same as section 4.1, except that the FPGA board is replaced. The following is a detailed test procedure.

■ Required Equipments

To enable an external loopback of transceiver channels, the following fixtures are required:

- HAN Pilot Platform and XTS-FMC card.
- 8 SMA cables for loopback the TX and RX ports on the XTS-FMC card.

■ Demonstration Setups

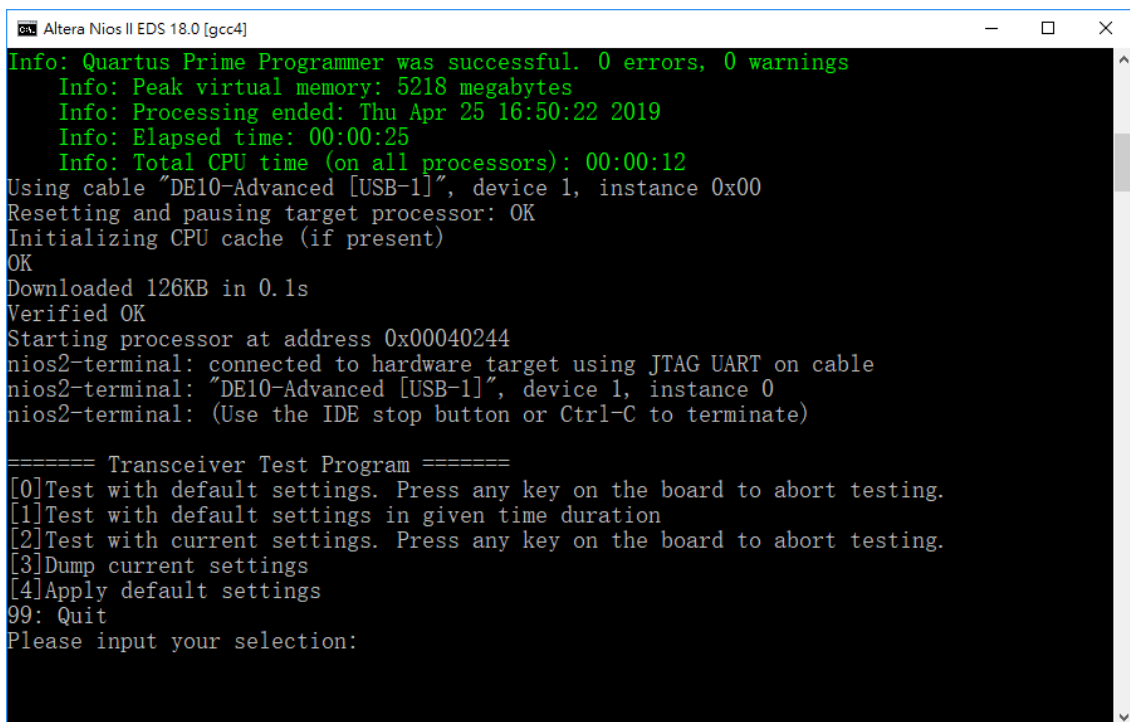
The transceiver test code is available in the folder System CD\Demonstrations\HAN\XCVT loopback. Here are the procedures to perform transceiver channel test:

1. Use the SMA cables to connect the TX ports and the RX ports on the XTS-FMC card to implement the loopback function (See Figure 4-6).
2. Connect the XTS-FMC card to the FMC connector of the HAN Pilot Platform board. Make sure the FMC connector between the two boards is locked with copper posts and screws (See section 1.3).



Figure 4-6 The Connections between the XTS-FMC and HAN Pilot Platform board

3. Connect your HAN board to your PC with a mini USB cable.
4. Connect Power to the HAN Pilot Platform board.
5. Copy the demo_batch folder (from System CD) to your local disk.
6. Power on the HAN Pilot Platform board.
7. Execute 'test.bat' in the demo_batch folder under your local disk.
8. The batch file will download .sof and .elf files, and start the test in the Nios-Terminal as shown in **Figure 4-7**. When the menu option appears, you can choose 0 for starting test. The program will automatically start the test and report the test results every five seconds until the user closes the window (see **Figure 4-8**).



```
Altera Nios II EDS 18.0 [gcc4]
Info: Quartus Prime Programmer was successful. 0 errors, 0 warnings
Info: Peak virtual memory: 5218 megabytes
Info: Processing ended: Thu Apr 25 16:50:22 2019
Info: Elapsed time: 00:00:25
Info: Total CPU time (on all processors): 00:00:12
Using cable "DE10-Advanced [USB-1]", device 1, instance 0x00
Resetting and pausing target processor: OK
Initializing CPU cache (if present)
OK
Downloaded 126KB in 0.1s
Verified OK
Starting processor at address 0x00040244
nios2-terminal: connected to hardware target using JTAG UART on cable
nios2-terminal: "DE10-Advanced [USB-1]", device 1, instance 0
nios2-terminal: (Use the IDE stop button or Ctrl-C to terminate)

===== Transceiver Test Program =====
[0]Test with default settings. Press any key on the board to abort testing.
[1]Test with default settings in given time duration
[2]Test with current settings. Press any key on the board to abort testing.
[3]Dump current settings
[4]Apply default settings
99: Quit
Please input your selection:
```

Figure 4-7 The test program

```
Altera Nios II EDS 18.0 [gcc4]
XTS_FMC_x4-3: PASS, XferCnt:14016478976
===== Time Elapsed: 1 Minutes 15 Seconds =====
XTS_FMC_x4-0: PASS, XferCnt:15026130560
XTS_FMC_x4-1: PASS, XferCnt:15026306688
XTS_FMC_x4-2: PASS, XferCnt:15026441984
XTS_FMC_x4-3: PASS, XferCnt:14993065600
===== Time Elapsed: 1 Minutes 20 Seconds =====
XTS_FMC_x4-0: PASS, XferCnt:16002717184
XTS_FMC_x4-1: PASS, XferCnt:16002894336
XTS_FMC_x4-2: PASS, XferCnt:16003027328
XTS_FMC_x4-3: PASS, XferCnt:15969652096
===== Time Elapsed: 1 Minutes 25 Seconds =====
XTS_FMC_x4-0: PASS, XferCnt:16979205888
XTS_FMC_x4-1: PASS, XferCnt:16979384448
XTS_FMC_x4-2: PASS, XferCnt:16979518592
XTS_FMC_x4-3: PASS, XferCnt:16946142080
===== Time Elapsed: 1 Minutes 30 Seconds =====
XTS_FMC_x4-0: PASS, XferCnt:17955792384
XTS_FMC_x4-1: PASS, XferCnt:17955970816
XTS_FMC_x4-2: PASS, XferCnt:17956105088
XTS_FMC_x4-3: PASS, XferCnt:17922728448
===== Time Elapsed: 1 Minutes 35 Seconds =====
XTS_FMC_x4-0: PASS, XferCnt:18932379008
XTS_FMC_x4-1: PASS, XferCnt:18932557696
XTS_FMC_x4-2: PASS, XferCnt:18932691712
XTS_FMC_x4-3: PASS, XferCnt:18899315328
```

Figure 4-8 Test result

4.3 XTS-FMC SuperLite Loopback on the Han Pilot Platform

This section also describes the use of the XTS-FMC card to test the FPGA's RX/TX transceiver loopback on the HAN pilot platform, this XTS-FMC SuperLite Loopback demonstration is created based on [Intel High Speed Transceiver Demo Designs](#), we ported it to HAN Pilot Platform combined with XTS-FMC card, the data rate of the transceiver channel on the FMC connector runs at 12.5Gbps.

User can refer to [A10GX_SIBoard_SuperliteII_V3_4_lanes_10Gbps_QSFP+.pdf](#) document in the folder System CD\Demonstrations\HAN\A10GX_SIBoard_SuperliteII_V3_4_lanes_10Gbps_QSFP+.pdf for detail description.

■ Demonstration Setups

The transceiver test code is available in the folder System CD\Demonstrations\HAN\SuperLite Loopback\demo_batch. Here are the procedures to perform transceiver channel test:

1. Use the SMA cables to connect the TX ports and the RX ports on the XTS-FMC card to implement the loopback function (See [Figure 4-9](#)).
2. Connect the XTS-FMC card to the FMC connector of the HAN Pilot Platform board. Make sure the FMC connector between the two boards is locked with copper posts and screws (See [section 1.3](#)).



Figure 4-9 The Connections between the XTS-FMC and HAN Pilot Platform board

3. Connect your HAN board to your PC with a mini USB cable.
4. Connect Power to the HAN Pilot Platform board.
5. Copy the demo_batch folder (from System CD) to your local disk.
6. Power on the HAN Pilot Platform board.
7. Execute 'test.bat' in the demo_batch folder under your local disk.
8. The batch file will download .sof and .elf files, and start the test in the Nios-Terminal as shown in **Figure 4-10**. When the menu option appears, use can choose C to start the test, if the Nios-Terminal shows '0' all the time, it means that the loopback test is passed without error.

```

Altera Nios II EDS 16.1 [gcc4]
Select Action :
=====
1. Set all channels back to default and toggle Reset
2. Force Re-Alignment on Rx Path
3. Select Channel To Control
4. Show/Control Transceiver PMA Settings on Links
5. Insert Biterrors on Link <4 at a time>
6. Reset ErrorCounter
7. Show Status
8. Control Serial loopback
C. Refresh BER every 1 seconds
D. Input new BER Time Interval
E. Show Transceiver PMA Settings on all channels
G. Input new EyeQInterval time
S. Store all channel information in memory of Selected Channel
T. Store and compare with values stored in process S
X. Toggle XOFF to partner to stop/start sending traffic at remote side
Z. Dump channel content of selected channel
O. Perform ODI on selected channel
Q. Stop Test

Enter Choice :c
Show BER + ErrorCount every 1 seconds
Press any key + Enter to stop the loop
=====
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0
Link : BER      : 0

```

Figure 4-10 Start the test in the Nios-Terminal

9. The signal XCVR quality depends on the device (such as scope, SMA cables) which is connected to the XCVR REFCLK Input SMA connector, user needs to modify the PMA parameters. Choose the action 3 (*Select Channel to Control*) in the Nios-Terminal to change channel, then choose action 4 (*Show/Control Transceiver PMA Settings on Links*) to modify the PMA parameters. Based on our actual experiment, we provided a group of PMA parameters as shown in [Table 4-1](#), user can modify the PMA parameters by referring the values in .

Table 4-1 PMA parameters based on our actual experiment

VOD	29
PostTap	-9
PreTap	-1
other	Default

Revision History

Version	Change Log
V1.0	Initial Version (Preliminary)
V1.1	Add section 2.3
V1.2	Add section 4.3

Copyright © Terasic Inc. All rights reserved.