TOE10G IP loopback test instruction

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This document describes the instruction to run loopback demo on FPGA development board by using AB15-SFPFMC board. The demo is designed to run TenGEMAC IP loopback test for measuring the latency time and total run time. Two EMAC IPs are integrated in the system to compare the latency time between two IPs. First EMAC IP is DG TenGEMAC IP and another IP is Intel TenGEMAC IP. Other hardwares (TOE10G IP and PCS/PMA IP) to run with TenGEMAC IP are similar. User can set test parameters on FPGA board and monitor the hardware status on NiosII command shell.

1 Environment Setup

To perform TOE10G IP loopback demo, please prepare the following test environment, as shown in Figure 1-1.
1) Cyclone10 GX FPGA development board
2) Two optical cables with 2x10 Gb SFP+ transceiver (10G BASE-R) for two loopback network connections.
3) micro USB cable for JTAG connection (FPGA programming and JTAG UART), connecting between FPGA board and PC.
4) AB15-SFPFMC, provided by Design Gateway.
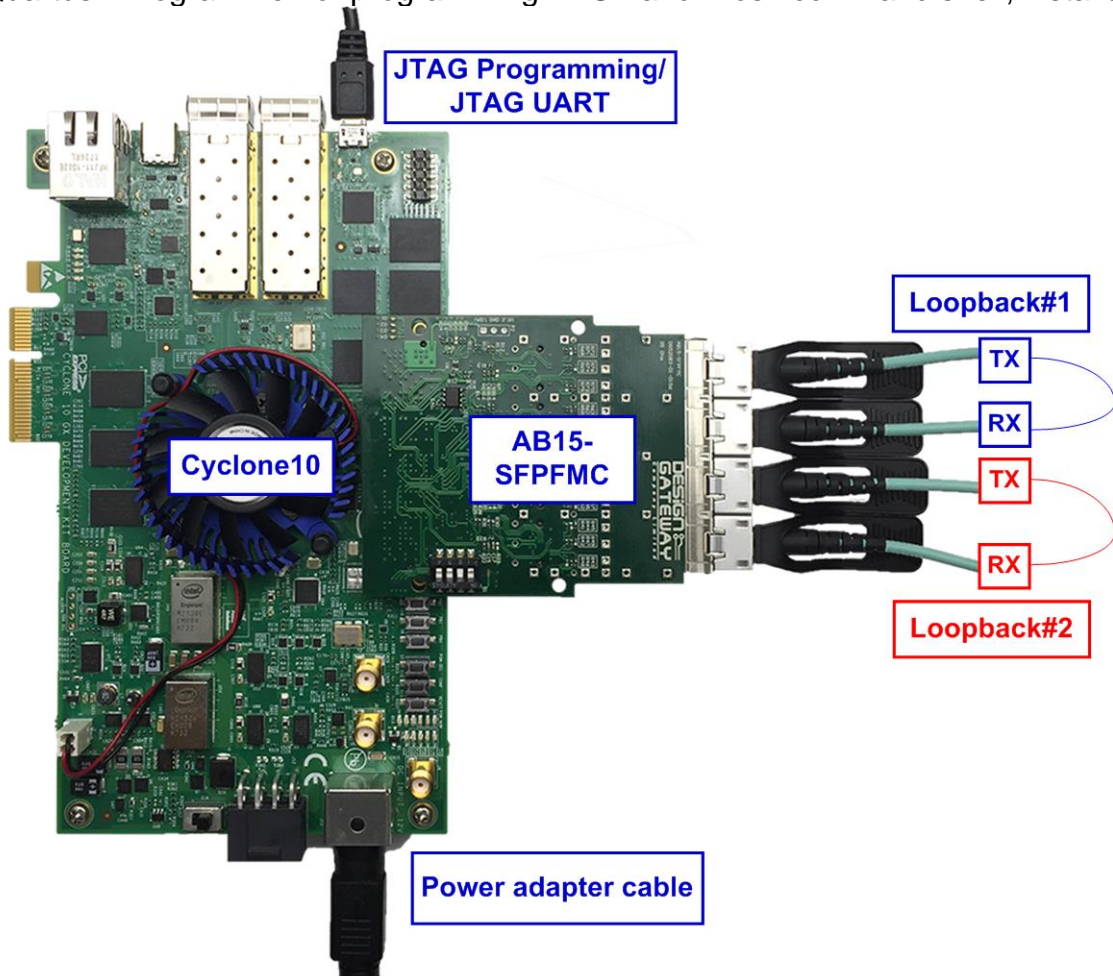5) QuartusII Programmer for programming FPGA and NiosII command shell, installed on PC

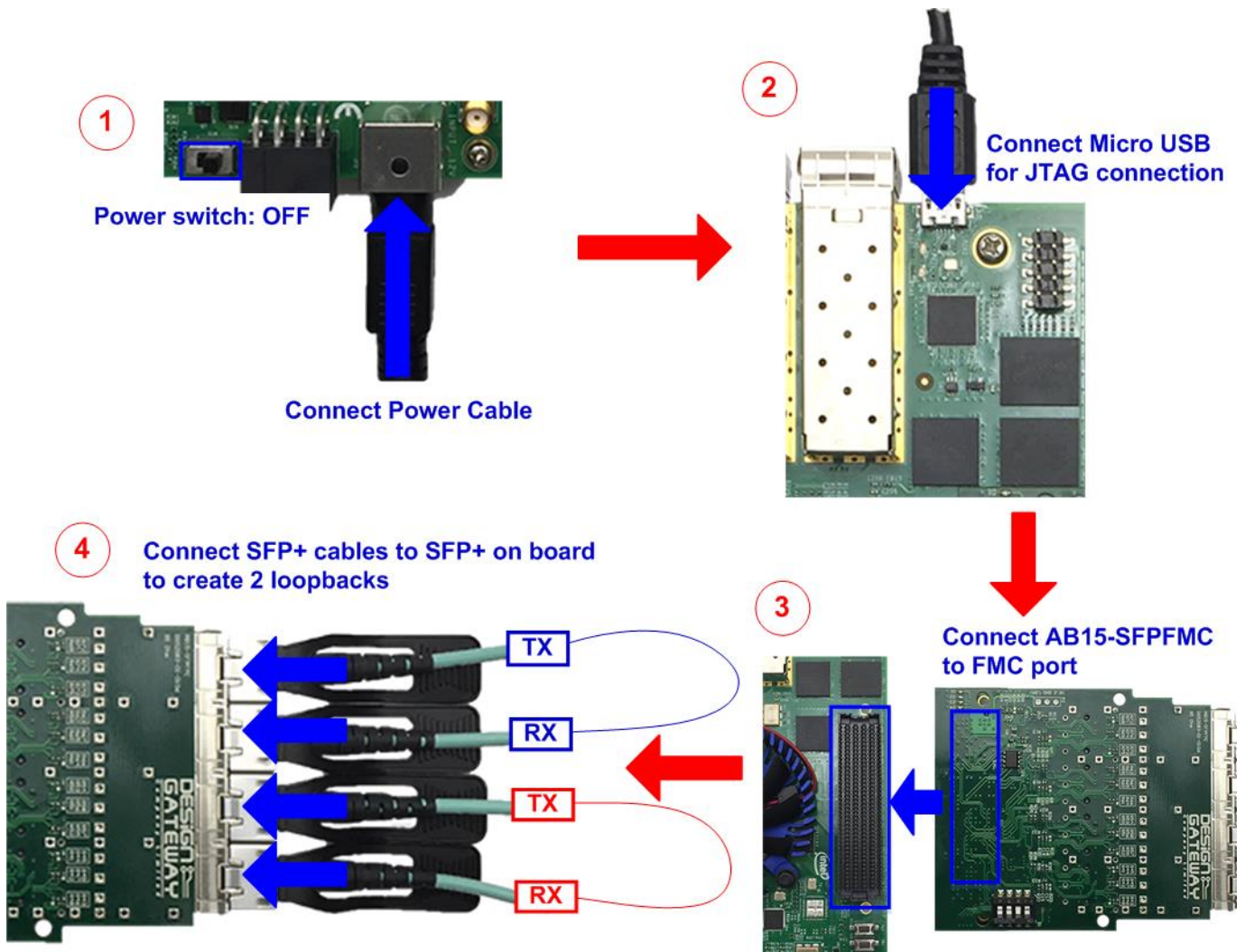Figure 1-1Test environment for the demo

2   Demo setup

Figure 2-1 FPGA board setup

1)   Turn off power switch and connect power supply to FPGA board.
2)   Connect FPGA board with PC by micro USB cable.
3)   Connect AB15-SFPFMC to FMC connector on FPGA board
4)   Insert SFP+ transceivers with optical cables to create two loopbacks as shown in Figure 2-1.
5)   Turn on power switch of FPGA board.

6) Open QuartusII Programmer to program FPGA through USB-1 by following steps.
   a. Click "Hardware Setup…" to select USB-BlasterII[USB-1].
   b. Click "Auto Detect" and select FPGA (10CX220YF780).
   c. Select Cyclone10 device icon.
   d. Click "Change File" button, select SOF file in pop-up window, and click "open" button.
   e. Check "Program".
   f. Click "Start" button to program FPGA.
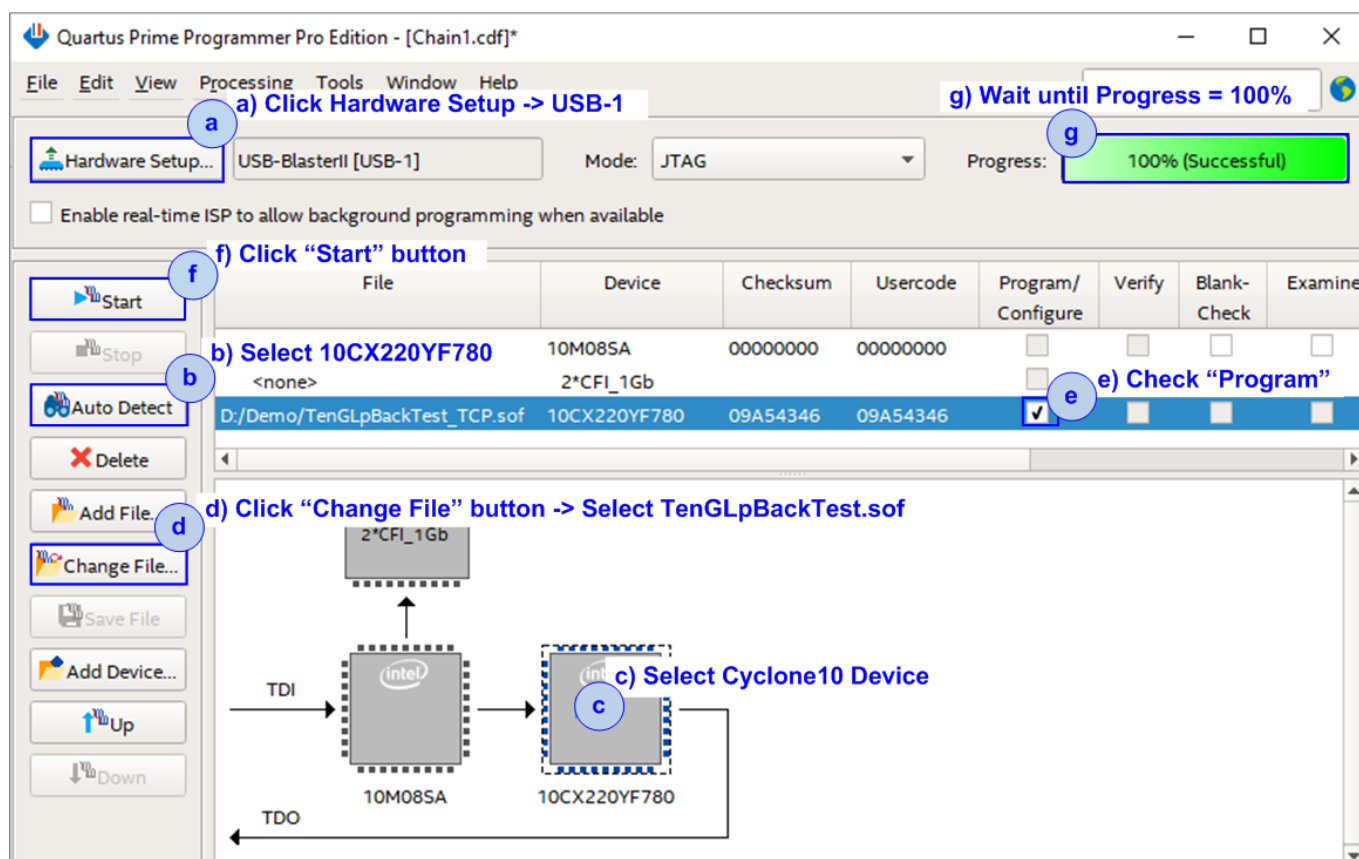   g. Wait until Progress status is successful.

Figure 2-2 FPGA Programmer

7) Open NiosII command shell.
   a. Type "nios2-terminal".
   b. Default parameters are displayed on the console.

Figure 2-3 NiosII command shell after boot-up

8) Enter 'x' to skip parameter setting. The default parameters are applied for system initialization, as shown in Figure 2-4. If other keys are entered, the menu to change parameter will be displayed. The example of changing parameter is shown in topic 3.2 (Reset Network parameters).
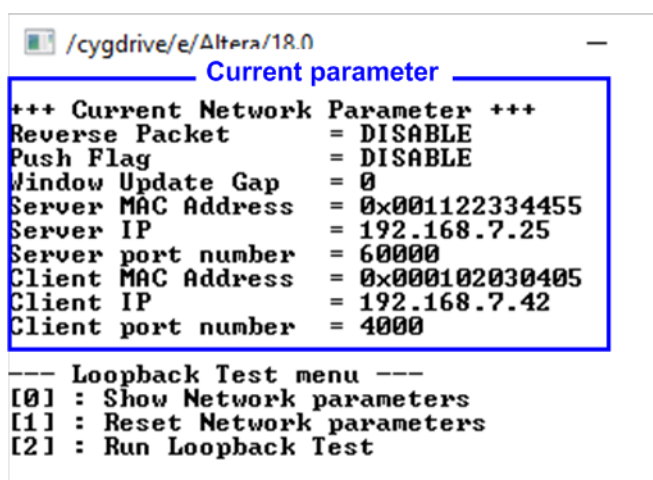

Figure 2-4 Initialization complete

3 Test menu

3.1 Show Network parameters

Select '0' to check current parameter in the demo. There are nine parameters displayed on the console. In this demo, both loopbacks share the same server and client network parameters.

One loopback consists of two TOE10G IPs. The server network parameters are applied to one TOE10G IP which sends data while the client network parameters are applied to another TOE10G IP which receives data.

Figure 3-1 Display current parameter result

1) Reverse Packet: Enable to send reverse data packet when received window of the target is too less for long time. '0': Disable the feature, '1': Enable to send reverse data packet. The default value is '1'.
2) Push Flag: Enable to assert PSH flag to every transmit packet. When asserting this flag, the Rx TOE10G-IP raises the priority to return ACK packet without waiting the next packet or timeout. Push flag is recommended to enable when the small size packet is applied.
3) Window Update Gap: Set threshold value to transmit window update packet. Valid value is 0x00 – 0x3F (0-63). The unit size of threshold value is 1 Kbyte. Default value is 0 (disable window update feature).
4) Server MAC address: 48-bit hex value to be MAC address of server. Default value is 0x001122334455.
5) Server IP: IP address of server. Default value is 192.168.7.25.
6) Server port number: Port number of server. Default value is 60000.
7) Client MAC address: 48-bit hex value to be MAC address of client. Default value is 0x000102030405.
8) Client IP: IP address of Client. Default value is 192.168.7.42.
9) Client port number: Port number of client. Default value is 4000.

To change some parameters can be done by using menu [1] Reset Network parameters.

3.2   Reset Network parameters

Select '1' to reset the IP or change IP parameters. This menu is used to change IP parameters or send reset to all TOE10G IP. After user selects this menu, the current parameters are displayed on the console. Enter 'x' to use same parameters and send reset to all TOE10G IPs. Other keys are entered to change some parameters and then reset TOE10G IPs.

There are nine parameters to set in this menu. Each of parameters is verified by CPU. The parameters are updated to TOE10G IP when the input is valid. If the input is not valid, the value will not change. After user assigns all parameters, TOE10G IP is reset. The description of each parameter is shown in topic 3.1 (Show Network parameter) and the range of each parameter is described as follows.

1) Reverse Packet: '0'-Disable reverse data packet, '1'-Enable reverse data packet. Default is '0'.
2) Push Flag: '0'-Set PSH flag of transmitted packet to '0', '1'-Set PSH flag of transmitted packet to '1'. Default value is '0'.
3) Window Update Gap: Set threshold value to transmit window update packet. Valid value is 0x00 – 0x3F (0-63). The unit size of threshold value is 1 Kbyte. Default value is 0 (disable window update feature).
4) Server MAC address: Input 12 digit of hex value. Add "0x" as a prefix to input as hex value.
5) Server IP address: A set of four decimal digits is separated by ".". The valid range of each decimal digit is 0-255.
6) Server port number: Valid range is 0-65535.
7) Client MAC address: Input 12 digit of hex value. Add "0x" as a prefix to input as hex value.
8) Client IP address: A set of four decimal digits is separated by ".". The valid range of each decimal digit is 0-255.
9) Client port number: Valid range is 0-65535.

After user assigns all parameters, new parameter set is displayed on the console. Next, reset signal is sent to the TOE10G IPs to load new parameter set to all TOE10G IPs in the design. Finally, "IP initialization complete" is shown after all TOE10G IPs finish initialization process, as shown in Figure 3-2.

Figure 3-2 Change Network parameters result

3.3 Run Loopback Test

Select '2' to run the loopback test of both loopbacks on FPGA. User enters test parameters on FPGA through NiosII command shell. The sequence to run the test is shown as follows.

1) On NiosII command shell, enter three parameters under run loopback test menu.
   a) Input transfer byte size: Unit of transfer size is byte. Valid value is 0x8 - 0xFFFFFFF8. The value must be aligned to 8. The input is decimal when only digit number is assigned. User can add "0x" as a prefix when the input is hexadecimal.
   b) Input packet byte size: Unit of packet size is byte. Valid value is 8 – 8960. The value must be aligned to 8. The input is decimal when only digit number is assigned. User can add "0x" as a prefix when the input is hexadecimal.
   c) Input number of loops: Valid value is 0x1 – 0xFFFFFFFF. Number of loops to repeat the test with the same inputs as a) and b). The input is decimal when only digit number is assigned. User can add "0x" as a prefix when the input is hexadecimal.
2) After all parameters are given and valid, both loopbacks start transferring data at the same time. Server TOE10G IP sends data to client TOE10G IP in the same loopback. All timers run to measure latency and usage time in the transfer process. During transferring data, the transmitted data size and the received data size are displayed on the console every second.
3) "Transfer data completed" is displayed on the console after all data are sent and received in the loopbacks. Finally, total transfer size, performance, and latency of both loopbacks are displayed as shown in Figure 3-3.
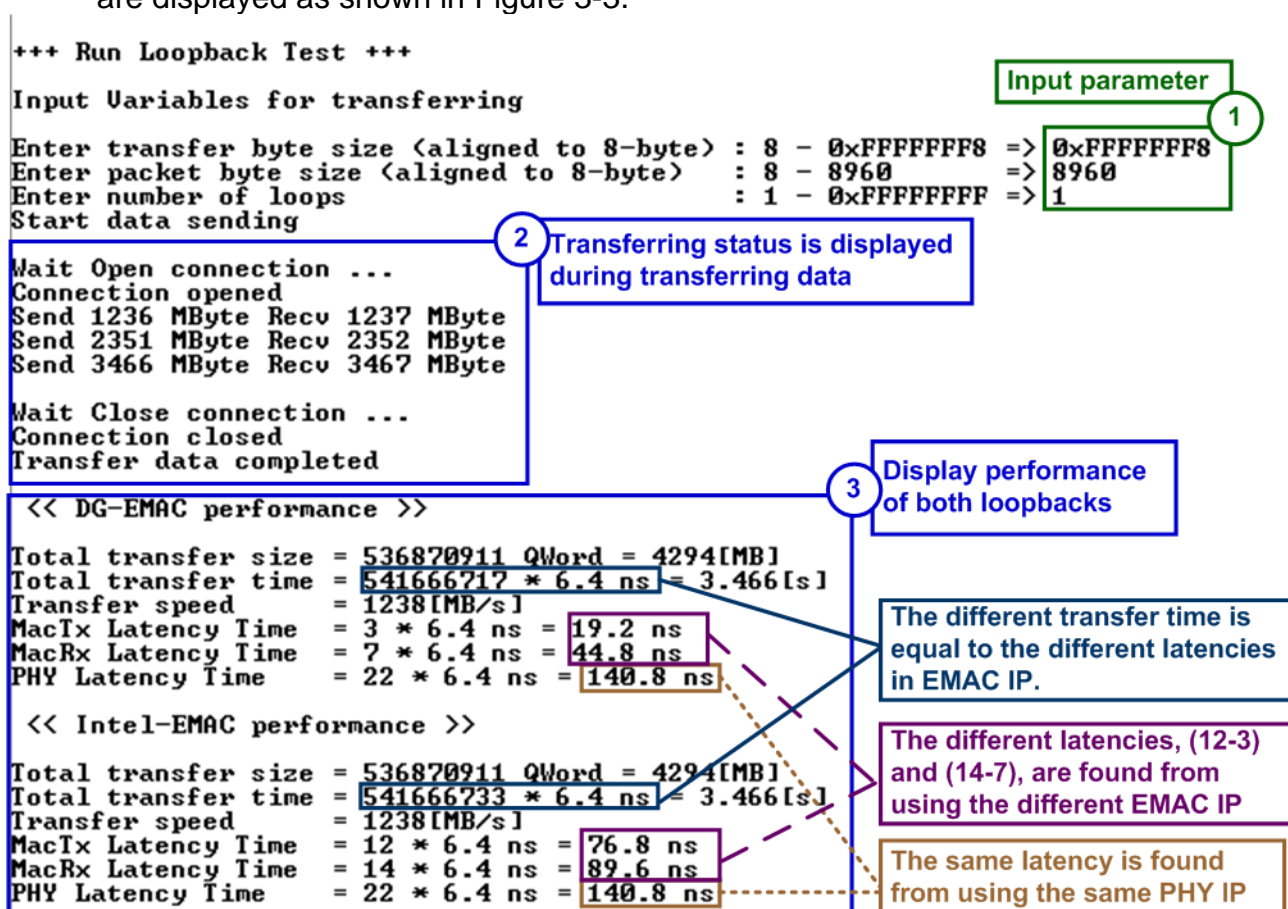

Figure 3-3 Loopback test with maximum transfer size and packet size for 1 loop

There are six values displayed as the performance result in Figure 3-3.
   a) Total transfer size: Total received size which is sum of the size in each loop. The value is displayed in 64-bit (Qword) unit and B(Byte)/KB(KiloByte)/MB(MegaByte).
   b) Total transfer time: Total run time displayed in clock cycle unit. One clock cycle is equal to 6.4 ns. Total time in s(second}/ms(millisecond)/us(microsecond) unit is displayed. The time duration is only measured when data is transferring in the loopback. The time using for other operations in CPU such as sending command process and calculation process is not included.
   c) Transfer speed: Performance which is calculated from total transfer size and total transfer time. The unit of transfer speed is B/s (byte per second), KB/s (KiloByte per second), or MB/s (MegaByte per second).
   d) MacTx Latency Time: The latency time of Tx data path within TenGEMAC IP in clock cycle unit (6.4 ns per 1 clock cycle) and nanosecond unit.
   e) MacRx Latency Time: The latency time of Rx data path within TenGEMAC IP in clock cycle unit (6.4 ns per 1 clock cycle) and nanosecond unit.
   f) PHY Latency Time: The latency time of physical layer and external hardware for loopback connection in clock cycle unit (6.4 ns per 1 clock cycle) and nanosecond unit.

The results from two loopback designs are displayed for performance comparison. The different module is EMAC IP, so Tx latency time and Rx latency time within EMAC is different. But PHY latency time is same.

As shown in Figure 3-3,
   - MacTx latency time of DG EMAC is less than Intel EMAC about 9 clock cycles.
   - MacRx latency time of DG EMAC is less than Intel EMAC about 7 clock cycles.
   - So, total transfer time of DG EMAC is less than Intel EMAC about 16 clock cycles (9 + 7).
The different latency time in EMAC IP has much effect when transfer size per loop is less.

As shown in Figure 3-4, the test result by using minimum size is displayed. In this case, total time of DG EMAC is less than total time of Intel EMAC about 10% ((152-136)/152).

Figure 3-4 Loopback test with minimum transfer size and packet size for 1 loop

The different time usage is much when running small packet size for many loops. Figure 3-5 shows the test result when the size is 8 byte and runs for 1,000,000 loops.

Figure 3-5 Loopback test with minimum transfer size and packet size for 1,000,000 loops

When running the loopback test by using the small transfer size which is less than 1456, TOE10G IP will not immediately return the received data to user after finishing the packet validation. TOE10G IP will wait the additional data until the timeout is found. After timeout, the data is ready for user reading from TOE10G IP.

To reduce the latency time for the small transfer size in the loopback test, the user can set Push flag parameter to "ENABLE", as shown in Figure 3-6.

Figure 3-6 Enable "Push Flag" parameter

As a test result, total transfer time is reduced from 136 to 88 clock cycles for DG EMAC and 152 to 104 clock cycles for Intel EMAC as shown in Figure 3-7.

Figure 3-7 Test result after setting PSH flag

If the input is invalid, "Out-of-range input" will be displayed and the operation will be cancelled, as shown in Figure 3-8-Figure 3-10.
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Figure 3-8 Error from invalid transfer size

Figure 3-9 Error from invalid packet size

Figure 3-10 Error from invalid number of loops

4 Revision History

Revision	Date	Description
1.0	15-Aug-19	Initial version release