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App Note - Using PCI Express

Revision history

Revision	Date	Comments
1.0	March 2013	First edition.
1.1	April 2013	Update for release 6.2.0 of software tools
1.2	June 2013	Updated for release 6.3.0 Kernel-specific build
1.3	September 2013	Added PCI Express validation section
1.4	July 2014	Up to date for Sotfware Tools Release 6.6
1.5	September 2015	Up to date for Software Tools Release 7

To ensure the accuracy of the information contained herein, particular attention was given to usage in preparing this document. It corresponds to the product version manufactured prior to the date appearing on the title page. There may be differences between the document and the product, if the product was modified after the production of the document.

Nutaq reserves itself the right to make changes and improvements to the product described in this document at any time and without notice.

Table of Contents

1 Introduction

The Perseus hardware and the host Linux PC must have their respective PCIe driver installed before running a PCIe example. This document presents a description of the steps required to perform these installations.

2 PCIe Link Validation

2.1 Ports 4-7 or 8-11?

Nutaq's PCI Express core can be instantiated either on ports 4-7 or ports 8-11 of the Perseus601x standard AMC connector. The Perseus611x product, only allows the core to be instantiated on ports 4-7. The user must pay special attention to which of these ports are supported by the system.

2.1.1 PCI Express in a uTCA Chassis

In a uTCA chassis, ports 4-7 and 8-11 can be either routed point to point between each of the chassis slots, or routed to a MCH card with a PCI Express switch, which can be slotted in the ports 4-7 or 8-11 MCH slots.

2.1.2 PCI Express with the PicoSDR and PicoDigitizer

In a PicoSDR and PicoDigitizer, ports 8-11 are always routed point-to-point between the sites A and B of the product. Ports 4-7 however are either routed point-to-point between sites A and B (default configuration for Pico devices with an embedded PC) or routed between emplacement A and the external PCI Express connector (default configuration for Pico devices without an embedded PC).

To use the PCI Express within a uTCA chassis or a PicoSDR/PicoDigitizer, the user must first understand what inter-slot connections are available and then configure their PCI Express core accordingly.

2.2 Link Validation

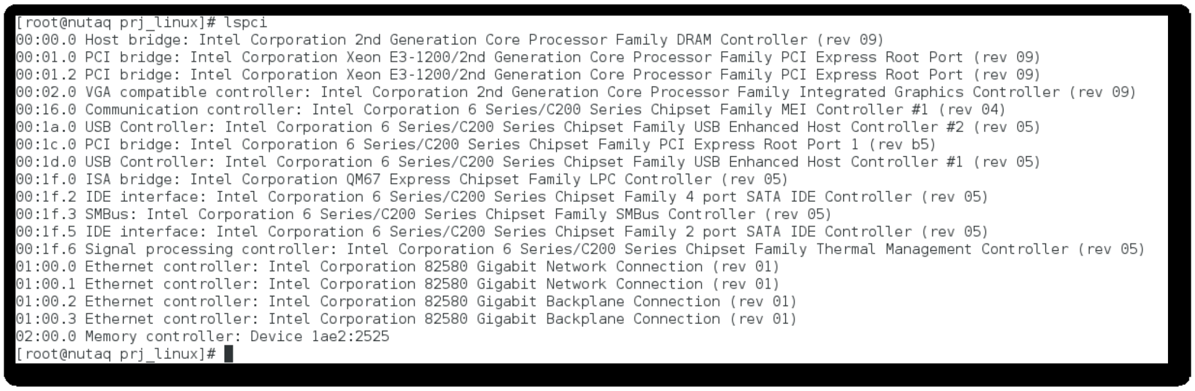
Once the FPGA design is compiled with the PCIe core, write the resulting configuration file to the Perseus flash memory and reboot your device.

Important

When booting the system after the configuration file has been programmed to flash, it is critical to hold the PC (whether the embedded PC blade or the external PC) in hardware reset while the Perseus configures itself, i.e. the PC must be held powered off until the Perseus boot procedure is complete.

Once the Perseus is configured, the PC can be powered on. Upon startup, the PC will enumerate all PCI Express devices in the system. Follow this procedure to confirm the PCI Express link is up.

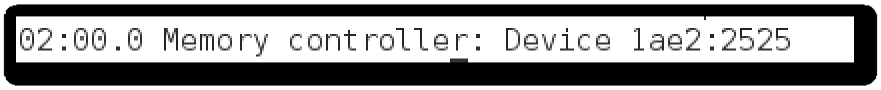
1. Log in a Linux session.
2. Open a terminal session.
3. Enter the *lspci* command to list all PCI Express devices and press enter.



```
[root@nutaq prj_linux]# lspci
00:00.0 Host bridge: Intel Corporation 2nd Generation Core Processor Family DRAM Controller (rev 09)
00:01.0 PCI bridge: Intel Corporation Xeon E3-1200/2nd Generation Core Processor Family PCI Express Root Port (rev 09)
00:01.2 PCI bridge: Intel Corporation Xeon E3-1200/2nd Generation Core Processor Family PCI Express Root Port (rev 09)
00:02.0 VGA compatible controller: Intel Corporation 2nd Generation Core Processor Family Integrated Graphics Controller (rev 09)
00:16.0 Communication controller: Intel Corporation 6 Series/C200 Series Chipset Family MEI Controller #1 (rev 04)
00:1a.0 USB Controller: Intel Corporation 6 Series/C200 Series Chipset Family USB Enhanced Host Controller #2 (rev 05)
00:1c.0 PCI bridge: Intel Corporation 6 Series/C200 Series Chipset Family PCI Express Root Port 1 (rev b5)
00:1d.0 USB Controller: Intel Corporation 6 Series/C200 Series Chipset Family USB Enhanced Host Controller #1 (rev 05)
00:1f.0 ISA bridge: Intel Corporation QM67 Express Chipset Family LPC Controller (rev 05)
00:1f.2 IDE interface: Intel Corporation 6 Series/C200 Series Chipset Family 4 port SATA IDE Controller (rev 05)
00:1f.3 SMBus: Intel Corporation 6 Series/C200 Series Chipset Family SMBus Controller (rev 05)
00:1f.5 IDE interface: Intel Corporation 6 Series/C200 Series Chipset Family 2 port SATA IDE Controller (rev 05)
00:1f.6 Signal processing controller: Intel Corporation 6 Series/C200 Series Chipset Family Thermal Management Controller (rev 05)
01:00.0 Ethernet controller: Intel Corporation 82580 Gigabit Network Connection (rev 01)
01:00.1 Ethernet controller: Intel Corporation 82580 Gigabit Network Connection (rev 01)
01:00.2 Ethernet controller: Intel Corporation 82580 Gigabit Backplane Connection (rev 01)
01:00.3 Ethernet controller: Intel Corporation 82580 Gigabit Backplane Connection (rev 01)
02:00.0 Memory controller: Device 1ae2:2525
[root@nutaq prj_linux]# 
```

Figure 1 lspci typical results

4. The Perseus device is identified by the memory controller identifier present in the list.



```
02:00.0 Memory controller: Device 1ae2:2525
```

Figure 2 Memory controller identification

If this device is not present, the PCI Express link has not been configured correctly. The following problems might have occurred:

- The FPGA bitstream file flashed does not contain a valid PCI Express core.
- The PCI Express core in the FPGA bitstream is instantiated on ports not available in the system.
- The PC was not held in reset long until the Perseus boot was complete.

5. Once the PCI Express link is validated, the driver installation procedure must be followed in order to setup the RTDEx PCI Express system. The procedure to install the PCIe driver is detailed in chapter 3.

3 Installation of the PCIe Driver

3.1 Installing the PCI Express Driver on the Host

To install the PCI Express driver on the host PC, follow this procedure:

1. The PCI Express on the host must be built before use. To do so, you must first install the kernel-devel package corresponding to the kernel version of your Linux installation.

   Warning :

   The latest Linux Kernel on which the PCI Express driver has been tested is Kernel **3.11.10-301**. The PCI Express driver could possibly not build or execute properly if a newer Kernel is used.

   Nutaq will update the driver in the case a newer Kernel which affects the build and the execution of the PCI Express driver is released.

2. In the Linux Board and Systems (Release 7.0) installation browse to the */Nutaq/bas/sdk/host/pcie/driver/host* folder.

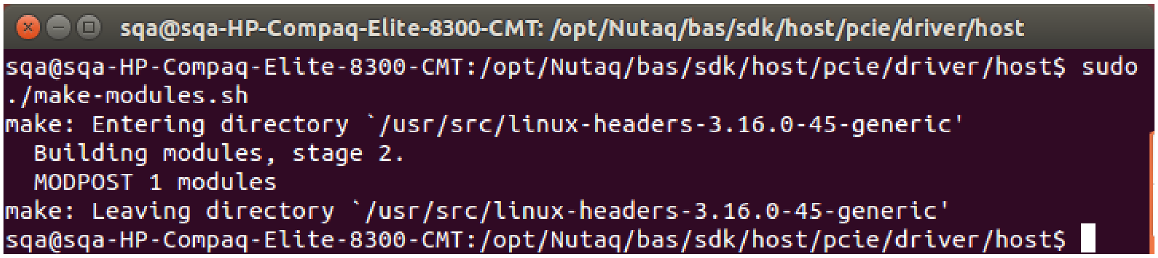
3. To install the driver, you must be logged as a super user. If it is not the case already, do so now.

   Note:

   A Perseus programmed with a bitstream containing the PCIe core must be present on the PCIe bus before proceeding to the next steps. If no such devices are present, the installation of the driver will fail.

4. Launch the make-modules.sh shell to build the Kernel Object. Use the ./ prefix.

   Example: ./make-modules.sh



sqa@sqa-HP-Compaq-Elite-8300-CMT: /opt/Nutaq/bas/sdk/host/pcie/driver/host

```
sqa@sqa-HP-Compaq-Elite-8300-CMT:/opt/Nutaq/bas/sdk/host/pcie/driver/host$ sudo
./make-modules.sh
make: Entering directory `/usr/src/linux-headers-3.16.0-45-generic'
  Building modules, stage 2.
  MODPOST 1 modules
make: Leaving directory `/usr/src/linux-headers-3.16.0-45-generic'
sqa@sqa-HP-Compaq-Elite-8300-CMT:/opt/Nutaq/bas/sdk/host/pcie/driver/host$ 
```

Figure 3 Expected results with make-modules.sh

5. Edit the setonpc.sh file.

   The last line of the files sets the address of the mailbox corresponding to the Perseus currently in the system. The PCIe software on the host uses a network interface emulation to simplify the mailbox transfers between the host and the FPGA. The command creates a new network interface on the Perseus which will use its IP address.

   The default value for the Host PCIe network interface is 192.168.101.99. To change the PCIe interface IP address edit this line in the file:

   ip addr add 192.168.101.99/24 dev mailbox0

   To use the mailbox, the Perseus mailbox IP address (defined in the setonperseus.sh file as 192.168.101.2 by default) must be on the same sub-network as the host PCIe network interface.

6. Launch setonpc.sh. (./setonpc.sh)

The setonpc.sh script must be run each time the host PC is started and the PCI Express is used.

7. Execute a PCIe example to verify that the installation was successful.

3.2 Installing the PCI Express Driver on the Perseus

The Perseus PCI Express driver gives the user the opportunity to use the PCIe link to control the Perseus. It is not necessary to install it to execute RTDEx PCIe transfers.

To install the Perseus PCI Express driver, follow this procedure:

1. Load a compiled PCIe bitstream to the Perseus FPGA.
2. In the Windows 7 installation, browse to the *%BASROOT%/sdk/host/pcie/driver/perseus* folder. Two files are present:
    - perseus_mailbox.ko : The Kernel Object is the pci express mailbox driver
    - setonperseus.sh: The shell file installs the Kernel Object on the Perseus.
3. setonperseus.sh assigns IP address 192.168.101.2 to the Perseus mailbox. Edit setonperseus.sh to change the IP address.
4. Connect to the FPGA using the Mestor mini-usb connector and Hyperterminal or an equivalent.
5. Through TFTP, load both files on the Perseus. Modify the IP address in the two following commands for the IP address of your TFTP server.

   To load the .ko file, run this command on the perseus command line (TFTP server address being 192.168.0.100):

   ```
   tftp -g -r perseus_mailbox.ko 192.168.0.100
   ```

   To load the .sh file, run this command on the perseus command line (TFTP server address being 192.168.0.100):

   ```
   tftp -g -r setonperseus.sh 192.168.0.100
   ```

6. Run the dos2unix command with the setonperseus.sh file as an argument in case the file was modified for transfer.
7. Enable the use of the setonperseus.sh using the chmod command.

   ```
   chmod 777 setonperseus.sh
   ```

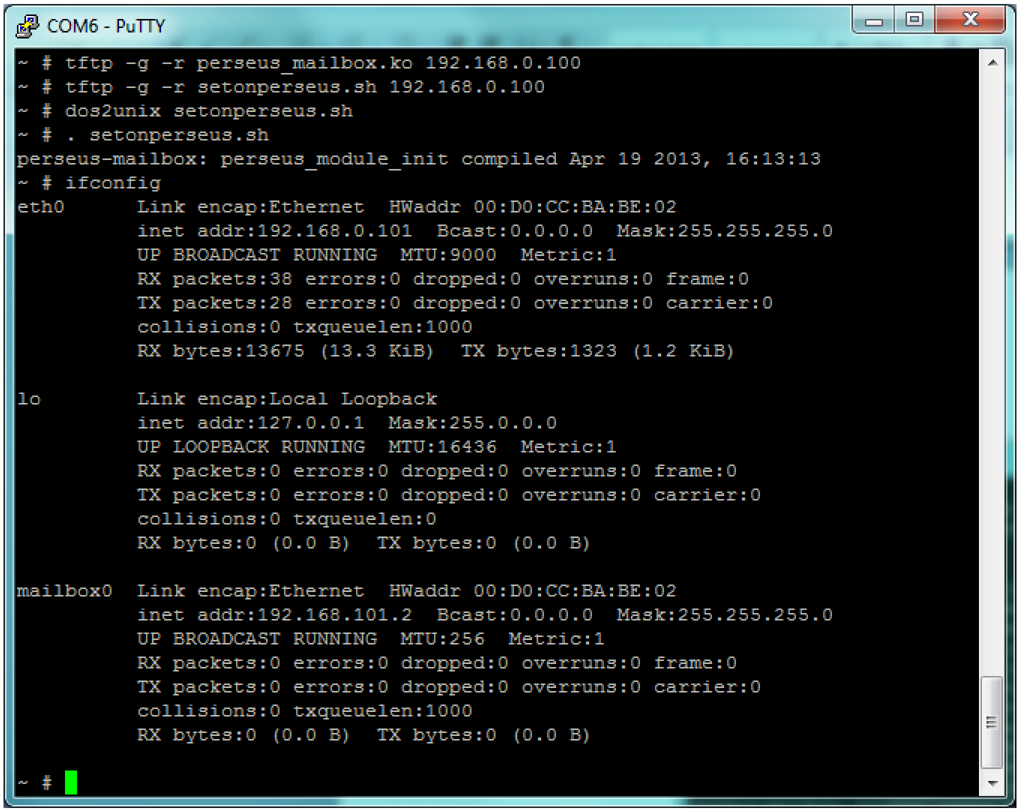
8. Launch the setonperseus.sh shell to run the driver installation. Use the ./ prefix.

   Example: ./setonperseus.sh

   The setonperseus.sh script must be run each time the Perseus is started and the PCI Express mailbox is used.

9. Verify the mailbox presence with *ifconfig.*

At this point, the command window should look like the one presented below.



```
~ # tftp -g -r perseus_mailbox.ko 192.168.0.100
~ # tftp -g -r setonperseus.sh 192.168.0.100
~ # dos2unix setonperseus.sh
~ # . setonperseus.sh
perseus-mailbox: perseus_module_init compiled Apr 19 2013, 16:13:13
~ # ifconfig
eth0      Link encap:Ethernet  HWaddr 00:D0:CC:BA:BE:02
          inet addr:192.168.0.101  Bcast:0.0.0.0  Mask:255.255.255.0
          UP BROADCAST RUNNING  MTU:9000  Metric:1
          RX packets:38 errors:0 dropped:0 overruns:0 frame:0
          TX packets:28 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:13675 (13.3 KiB)  TX bytes:1323 (1.2 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

mailbox0  Link encap:Ethernet  HWaddr 00:D0:CC:BA:BE:02
          inet addr:192.168.101.2  Bcast:0.0.0.0  Mask:255.255.255.0
          UP BROADCAST RUNNING  MTU:256  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

~ #
```

Figure 4 Expected results with setonperseus.sh