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Chapter 1: Introduction

Congratulations on your purchase of the DN9002K10PCI logic emulation board. If you are unfamiliar with Dini Group products, you should read Chapter 2, Quick Start Guide to familiarize yourself with the user interfaces the DN9002K10PCI provides.

Figure 1 DN9002K10PCI – shown with optional memory modules installed; User LEDs, power fail LEDs, and Gigabit activity LEDs all glow inexplicably. Heatsinks negligently left uninstalled.

1 Manual Contents

This manual contains the following chapters:

Introduction
Reader’s Guide to this manual; List of available documentation and resources available.

Quick Start Guide
Step-by-step instructions for powering on the DN9002K10PCI, loading and communicating with a simple, provided FPGA design, and using the board’s common control features.
INTRODUCTION

Controller Software
A summary of the functionality of the provided software. Implementation details for the remote USB board control functions and instructions for developing your own USB host software.

Hardware
Detailed description and operating instructions of each individual circuit on the DN9002K10PCI, a description of each user-accessible interface and user features.

The Reference Design
Detailed description of the provided DN9002K10PCI reference design. Implementation details of the reference design interaction with DN9002K10PCI hardware features.

Ordering Information
Contains a list of the available options and available optional equipment. Some suggested parts and equipment available from third party vendors. Compatibility lists.

2 Conventions
This document uses the following conventions. An example illustrates each convention.

2.1 Typographical
The following typographical conventions are used in this document:

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<th>Meaning or Use</th>
<th>Example</th>
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<td>Indicates hexadecimal notation</td>
<td>Read from address 0x00110373, returned</td>
</tr>
<tr>
<td>Letter “#”, “N”</td>
<td>Signal is active low</td>
<td>INT# is active low RSTn is active low</td>
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2.2 Manual Content
2.2.1 File names
Paths to documents included on the User CD are prefixed with “D:\”. This refers to your CD drive’s root directory when the User CD is inserted in your Windows computer.

Alternately, copy the entire contents of the User CD to your hard drive, and allow D:\ to refer to this path. Due to limitations of the Xilinx ISE software, we recommend a path without space characters in it. (Bad places include C:/Documents and Settings/username/Desktop/)

2.2.2 Physical Dimensions
By convention, the board is oriented as shown in the above board photo, with the “top” of the board being the edge near the DDR2 SODIMMs. The “right” edge is near FPGA B. The “left” side is the side with the PCI bezel. “Top” side refers to the side of the PWB with FPGAs and fans; the “back” side is the side with the two daughtercard connectors. The reference origin of
the board is the center of the lower PCI bezel mounting hole. Physical dimensions are given in millimeters.

2.2.3 Part Pin Names
References to individual part’s pin are given in the form <X><Y><Z>; The <X> is one of: U for ICs, R for resistors, C for capacitors, P or J for connectors, FB or L for inductors, TP for test points, MH for mounting structures, FD for fiducials, BT for sockets, DS for displays (light-emitting diodes), F for fuses, PSU for power supply modules, Q for discreet semiconductors, RN for resistor networks, G for oscillators, X for sockets, Y for crystals and the PCI bezel. <Y> is a number uniquely identifying each part from other parts of the same class. <Z> is the pin or terminal number or name, as defined in the datasheet of the part. Datasheets for all standard and optional parts used on the DN9002K10PCI are included in the Document library on the user CD.

2.2.4 Schematic Clippings
Partial schematic drawings are included in this document to aid quick understanding of the features of the DN9002K10PCI. These clippings have been modified for clarity and brevity, and may be missing signals, parts, net names and connections. Unmodified Schematics are included in the User CD as a PDF. Please refer to this document when designing an interface in the FPGA. Use the PDF search feature to search for nets and parts.

2.3 Terminology
Abbreviations and pronouns are used for some commonly used phrases. The user is assumed to know the meaning of the following:

Spartan
Spartan refers to the Spartan-3 FPGA device used by the DN9002K10PCI to perform configuration circuit functions. It is used interchangeably with “configuration circuit”

DCM, DLL, PLL
“Digital Clock Manager” or “Digitally-locked-loop”. This is a clock synthesis module in a Virtex-5 FPGA. PLL is “Phase-locked-loop”. See Xilinx documentation.

LVDS
“Low-Voltage differential signaling”. A signaling standard with a 1.2V DC, and 300mV AC level. In this manual and in advertisements, LVDS is often used where “Differential Signal” should be used instead.

Net, Signal, Plane, rail
A net is an electrically continuous piece of conductor on the PCB before assembly. Signal can refer to an electrically continuous conductor on the PCB, or to the logical meaning of that net. Plane is a net for voltage sources. Rail is also used to mean a power net.

GND, ground, grounded
GND is a net on the DN9002K10PCI, to which all voltages are referenced. “Ground” is
equivalent”. Grounded means “connected to GND”. There is a single ground net on the DN9002K10PCI.

3 Resources

The following electronic resources will help you during development with your board.

3.1 User CD

The User CD contains all the electronic documents required for you to operate the DN9002K10PCI. These include schematics, the user manual, FPGA reference designs, and datasheets. The directory structure of the CD is as follows:

- 3rdPartySoftware\Acrobat Reader 7.0\, Required to read .pdf documents (Windows)
- Config_Section_Code\, The DN9002K10PCI firmware source code.
  - Config\FPGA\, These sources are not intended to be used for development.
  - MCU\,
- Datasheets\, A datasheet for every part used on the board. You will need these to interface successfully with resources on the DN9002K10PCI.
- Documentation\Manual\, Contains this document
- FPGA_Reference_Designs\common\, Contains the source and compiled programming files for the Dini group’s DN9002K10-PCI reference design. Also, board description
  - Programming_Files\certify\,
- PCI_Software_Applications\Aetest\, Source and binaries for the provided PCI-hosted controller software.
- Schematics\Rev_01\, Contains a PDF version of the board schematic. Search the PDF using control-F. Also contains an ASCII netlist of the board.
- USB_Software_Applications\driver\USB_CMD_Line_AETEST_USB\USBController\, Contains source and binaries for the provided USB-hosted controller applications.
3.2 Dinigroup.com
The most recent versions of the following documents are found on the product web page http://dinigroup.com/index.php?product=DN9002K10PCI

User’s Manual (this document)
Certify Board Description File
Errata
USB Controller executable

3.3 Errata and Customer Notifications
The Errata sheet (available at www.dinigroup.com) lists all cases where the DN9002K10PCI is found to have failed to meet advertised specifications, or where an error in schematics or documentation is likely to cause a difficult-to-debug error by the user.

The customer is notified when there is an update to the Errata list after the board is shipped. Customers are not notified when changes are made to other documents including the reference design, USB Controller and User Manual. These documents change or a weekly basis or faster. You may always request a duplicate User CD. We will also be happy to provide the latest version of documents via email to customers.

3.4 Schematics and Netlist
Unmodified Schematics are included in the User CD as a PDF. Use the PDF search feature to search for nets and parts.

3.4.1 Netlist
In lieu of providing a machine-readable version of the schematic, the Dini Group provides a text netlist of the board. This netlist contains all nets on the board that connect to user IO on any FPGA. When interfacing with any device or connector on the DN9002K10PCI you should use either the provided ucf, or the netlist to generate the pinout. The netlist is located on the user CD at

D:\Schematics\Rev_01\DN9002K10PCI_customer_netlist.net

3.4.2 Net name conventions
All “power” nets begin with a +, - symbol, or GND

All clock signals begin with “CLK”

Two sides of a differential signal differ by one character “p” or “n”. This character is near the end of the net name.

Active low signals end in #. In the provided UCF files, the # is replaced by an “N”.

3.5 Datasheet Library
Datasheets for all parts used, or interfaced to, on the DN9002K10PCI are provided on the user CD. In order to successfully use the DN9002K10PCI, you will have to reference these datasheets. The interface descriptions given in this user manual typically end with electrical connectivity.

Especially read the Virtex-5 user guide. The copy provided on the user CD is only recent as of the DN9002K10PCI product announcement.

3.6 Xilinx
Virtex-5 is a brand-new device, and technical questions about getting the FPGA and ISE software to behave like you expect should be directed to a Xilinx FAE. Also use

WebCase http://www.xilinx.com/support/clearexpress/websupport.htm
AnswerBrowser http://www.xilinx.com/xlnx/xil_ans_browser.jsp
Virtex 5 Manual(s) http://www.xilinx.com/xlnx/xweb/xil_publications_display.jsp

3.7 Dini Group Reference Designs
The source code to the reference designs are on the User CD. Please copy and use any code you would like. The reference designs themselves are not deliverables, and as such receive limited support.

3.8 Board Models
Certify board models and other simulation models for the DN9002K10PCI are provided on the user CD.

D:\FPGA_Reference_Designs\DN9002K10PCI\certify

4 Email and Phone Support
Dini Group technical support for products can be reached via email at support@dinigroup.com. Our phone number is (USA) 858-454-3419. Please do not send .exe files, .vb files, or .zip files containing other .zip files as attachments, as we will not receive these emails. Please include the board’s serial number in your email. This will allow us to reference our records regarding your board.

Before contacting support you should complete the following:

1) Follow the debugging steps in the troubleshooting sections at the end of the hardware chapter, and in any applicable interface sections.

2) Test the applicable interface(s) using the provided software and .bit files, to help rule out hardware failures.
Chapter 2: Quick Start Guide

The Dini Group DN9002K10PCI can be used and controlled using many interfaces. In order to learn the use of the most fundamental interfaces of the board (FPGA Configuration, USB data movement, etc.) please follow the instructions in this quick start guide. The guide will also show you how to run the board’s hardware test to verify board functionality. (The board has already been tested at the factory).

1 Provided Materials

Examine the contents of your DN9002K10PCI kit. It should contain:

- DN9002K10PCI board
- CompactFlash card containing the FPGA configuration “.bit” files required to run the hardware test.
- USB CompactFlash card reader
- RS232 IDC header cable to female DB9
- USB cable, black.
- CD ROM containing:
  - Virtex 5 Reference Designs
  - User manual PDF
  - Board Schematic PDF
  - USB program (usbcontroller.exe)
  - PCI program (Aetest.exe)
  - Source code for USB program, PCI program and DN9002K10PCI firmware
  - Board netlist, certify model, and QL5064 simulation model

1.1 System Requirements

To compile Verilog designs for Virtex 5, ISE 9.1 may be required. For LX330 designs, you may need a Linux machine with a 64-bit processor and 6GB of RAM or greater. (Windows XP limits memory to 3GB)

To use the provided controller software, you need any Windows XP computer with USB 2.0.

To receive firmware updates to the DN9002K10PCI, you need a JTAG programming cable from Xilinx. Having this cable is basically mandatory, otherwise you would need to ship the board back to us to enable features or correct firmware bugs. You probably need a JTAG cable.
anyway for using embedded debugging software. We recommend the Xilinx Platform USB cable over their Parallel IV, because it sucks less.

2 Warnings

2.1 ESD
The DN9002K10PCI is sensitive to static electricity, so treat the PCB accordingly. The target markets for this product are engineers that are familiar with FPGAs and circuit boards. However, if needed, the following web page has an excellent tutorial on the “Fundamentals of ESD” for those of you who are new to ESD sensitive products:

http://www.esda.org/esd_fundamentals.html

Figure 2 - Bzzzzzzt!!

There are two large grounded metal rails on the DN9002K10PCI. The user should handle the board using these rails, as they are much less ESD sensitive than any other point on the board.

The 400-pin connectors are not 5V tolerant. No exposed surfaces on the board, except for the PCI edge connector are tolerant of voltages greater than 4V. According to the Virtex 5 datasheets, the maximum applied voltage to any IO signals on the FPGA is VCCO. This means you should not try to over-drive IOs in an FPGA interface above the interface voltage specified in this manual.

2.2 Other
Some parts of the board are physically fragile. Take extra care when handling the board to avoid touching the daughtercard connectors. Leave the covers on the daughtercard connectors whenever they are not in use. Use mounting hardware to secure daughtercards.

2.3 Other, speculative

Do not touch high-voltages.
Do not shatter the user CD.

Do no insert clovers into PC.

Do not pour orange soda onto electronics.

Do not children play with packaging.

Do not let children taste wires.

Do not start smoking. It’s bad for your health.

3 Pre-Power on Instructions

The image below represents your DN9002K10PCI. You will need to know the location of the following parts referenced in this chapter.
The FPGAs on the board are named “FPGA A” through “FPGA F”. FPGA A is in the lower left hand corner as shown in the above photo. FPGA B and C are to its right. The top row of FPGAs from left to right be named, “FPGA D”, “FPGA E”, and “FPGA F”.

To begin working with the DN9002K10PCI, follow the steps below.

### 3.1 Install Memory
The DN9002K10PCI comes packaged without memory installed. If you want the Dini Group reference design to test your memory interfaces, you must install memory modules in the SODIMM slot on the board. The reference design supports DDR2 SODIMM modules in densities 256MB, 512MB, and 1GB with a CAS latency of 3. (Almost any modern off-the-shelf laptop memory)

The socket DIMMB is connected to FPGA B. The socket can accept any capacity DDR2 SODIMM module. Note that DDR1 modules will not work in these slots since they are a completely different pin-out and voltage level.

### 3.2 Prepare configuration files
The DN9002K10PCI reads FPGA configuration data from a CompactFlash card. To program the FPGAs on the DN9002K10PCI, FPGA design files (with a .bit file extension) put on the root directory of the CompactFlash card file using the provided USB card reader.

The DN9002K10PCI ships with a 256MB CompactFlash card preloaded with the Dini Group reference design. These “bit” files can also be found on the User CD. You can also compile the reference design source (provided on the CD) and place the generated .bit files on the Compact Flash card.
1. Insert the provided CompactFlash card labeled “Reference Design” into your USB card reader. Make sure the card contains the files:

   FPGA_A.bit  
   FPGA_B.bit  
   main.txt

The files FPGA_A-F.bit are files created by the Xilinx program bitgen, part of the ISE 8.2 tools. The file main.txt contains instructions for the DN9002K10PCI configuration circuitry, including which FPGAs to configure, and to which frequency the global clock networks should be automatically adjusted.

2. Insert the CompactFlash card into the DN9002K10PCI’s CompactFlash slot.

### 3.3 Install DN9002K10PCI in computer

If you are not using the DN9002K10PCI in a PCI slot, skip this step. You may instead choose to host the DN9002K10PCI over USB.

The DN9002K10PCI is compatible with 3.3V or 5V PCI slots, either 64 or 32 bit. If the motherboard is 32 bit, then half of the edge connector will extend beyond the PCI slot. Do not plug the DN9002K10PCI into a slot backwards. It will fit, but this is wrong and potentially damaging with fire. The DN9002K10PCI can also be used in a PCI-X slot.

The rest of this chapter assumes you are installing the board into a Windows XP computer. The DN9002K10PCI and provided software is compatible with other operating systems, but there is no corresponding quick start guide.

### 3.4 Cables

#### 3.4.1 Connect RS232 Cable

The configuration circuit displays status messages to an RS232 terminal. If (when) something goes wrong with configuration, this terminal will output error messages. Normally, you would only connect this cable when something is not working and you want to debug the problem.

Use the provided ribbon cable to connect the MCU RS232 port (P3) to a computer serial port to view feedback from the configuration circuitry during FPGA configuration. Run a serial terminal program on your PC (On Windows you can use HyperTerminal Start->Programs->Accessories->Communications->HyperTerminal) and make sure the computer serial port is configured with the following options:

- Bits per second: 19200
- Data bits: 8
- Parity: None
- Stop Bits: 1
- Flow control: None
- Terminal Emulation: VT100 (or None, if available)
3.4.2 Connect USB Cable
Use the provided USB cable to connect the DN9002K10PCI to a Windows computer (Windows XP is recommended).

If your board is installed in a PCI slot, the USB host is allowed to be the same computer as the non-USB host. The two computers should be connected to the same power outlet if this is the case.

3.4.3 Connect Power cable
If you are using PCI as a host interface, skip this step. In a PCI slot, the board operates using only the power provided by the slot. Do not use a separate external power supply in P1 or J8 if you are using the DN9002K10PCI in a PCI slot.

Connect an ATX power supply to J8 (20-pin power connector).

Note that if you have an Antec 400-Watt power supply, it comes with an adjustable-voltage faceplate. If this is not connected, then the power supply will output a low voltage and fail to power on the DN9002K10PCI, and you will likely call and complain.

Many power supplies have a minimum load for 12V. Since the DN9002K10PCI does not use this voltage, this minimum will not be met. Under stressful situations, the power supply’s 5V power rail might become unstable, causing the DN9002K10PCI to automatically reset. The reference design is not particularly stressful to the power supply and will probably not cause this to occur. To work around this limitation, you can

- Use a power supply that does not have a minimum 12V load
- Attach a dummy load to one of the 4-pin “hard drive” connectors. (Like an old hard drive, or your tongue)
- Avoid high power load transients in your FPGA design

4 Power On

Turn on the ATX power supply (USB Hosting) or the computer (PCI hosting).

When the DN9002K10PCI powers on, it automatically loads Xilinx FPGA design files (ending with a .bit extension), found on the CompactFlash card in the CompactFlash slot into the FPGAs, using the main.txt file as a guide.

4.1 View configuration feedback over RS232
As the DN9002K10PCI powers on, your RS232 terminal (connected to P3) will display information about the Configuration process. If FPGAs ever fail to configure using the Compact Flash card, this is the best place to look for help.

A typical RS232 power-on session is given below.
QUICK START GUIDE

Rebooting from FLASH...please wait

Setting G0...
N: 01 M: 000001000
DONE
Setting G1...
N: 01 M: 000001000
DONE
Setting G2...
N: 01 M: 000001000
DONE

== DN9002K10PCI MCU FLASH BOOT ==

-- FPGAS STUFFED --
A B

-- COMPACTFLASH INFO --
MAKER ID: EC
DEVICE ID: 75
SIZE: 32 MB

-- FILES FOUND ON COMPACTFLASH CARD
FPGA_B.BIT
FPGA_A.BIT
MAIN.TXT

-- CONFIGURATION FILES --
FPGA A: FPGA_A.BIT
FPGA B: FPGA_B.BIT

-- OPTIONS --
Message level set to default: 2
Sanity check is set to default: ON
N: 00 M: 000001010
DONE
Setting G0...
N: 01 M: 00001100
DONE
Setting G1...
N: 01 M: 00001000
DONE

******CONFIGURING FPGA: A************

-- Performing Sanity Check on Bit File --
-- BIT FILE ATTRIBUTES --
FILE NAME: FPGA_A.BIT
FILE SIZE: 003A943B bytes
PART: 4vlx100ff151317:09:38
DATA: 2005/07/25
TIME: 17:09:38
Sanity check passed

.........DONE WITH CONFIGURATION OF FPGA: A

******CONFIGURING FPGA B************

-- Performing Sanity Check on Bit File --
-- BIT FILE ATTRIBUTES --
FILE NAME: FPGA_B.BIT
FILE SIZE: 003A943B bytes
PART: 4vlx100ff151317:05:01
DATA: 2005/07/19
TIME: 17:05:01
Sanity check passed

The board is setting the global clock frequencies according to the
main.txt file on the CompactFlash card. The messages here are mostly
only useful to whoever programmed the firmware

This lists the files found on the compact flash card. If this list is
wrong there is something wrong with CompactFlash.

This line has to do with the firmware-update mode

The MCU reads the contents of the file MAIN.TXT and executes
each instruction line.

Here the MCU is setting the clocks according to instructions in
MAIN.TXT

The MCU is configuring FPGA A according to instructions in
MAIN.TXT

Debugging information about the .bit file.

The MCU is configuring FPGA B according to instructions in
MAIN.TXT

CompactFlash card debugging information.
## 4.2 Check LED status lights

The DN9002K10PCI has many status LEDs to help the user confirm the status of the configuration process.

1. Check the power Failure LEDs to confirm that all voltage rails of the DN9002K10PCI are within tolerance. If the voltage of any critical power net on the DN9002K10PCI is too high or too low, the board will be held in reset and at least one of the red LEDs will light. The LEDs are located on the top edge, near the left corner of the PCB. Each one is labeled with the voltage that it represents. Normally, all of these LEDs are off. If any of these LEDs light, there is a power problem with the board, and you should contact us. First, make sure that the output of the power supply is acceptable. If the 5V, 3.3V or 12V power fail LED is lit, you most likely have a problem with the power supply you are connected to, and less likely with the DN9002K10PCI.

2. Reset LED. When the board is in reset for any reason, including power failure, or pressing the reset button, this LED will light RED. The LED is located below the RED voltage LEDs next to the logic-reset button.

3. Check the Spartan FPGA status LED located near pin 1 of the PCI edge connector (DS56). This LED should remain GREEN as long as the board is powered on, except for a quarter second just as the board is powering on. This LED indicated the configuration and control FPGA is on. If this LED is not on, it indicates a problem with the board or firmware.

4. Check the “DONE” LEDs of each FPGA. When an FPGA is configured, a green LED labeled “DONE” will glow, to the upper left of the FPGA.

5. Check the FPGA A user LEDs located just below the FPGA A. These LEDs should be active if the Dini Group reference design is correctly loaded. Repeat this step for FPGAs B. These Yellow LEDs are lined up horizontally below the FPGAs.

6. Check the CF activity LED, located just below the CompactFlash socket. When the board is reading off the CompactFlash card during configuration, this yellow LED should blink.
5 Run USB Controller

This section will get you started with USB and show you how to operate the provided software.

5.1 Driver Installation

When the DN9002K10PCI powers on, or you connect it to a USB port for the first time, the computer will ask you to install a driver.

In the window that appears, select “Install from a list or specific location”. Select Next.

Click “Include this location in the search” and browse to D:\USB_Software_Applications\driver\windows_wdm
Select Next.

In the next window, select the item in the list “Dini Group ASIC Emulator”. Click FINISH.

After Windows installs the driver, you will be able to see the following device in the “USB Controllers” group in the Windows device manager: “Dini Group ASIC Emulator”.

<Update: it might be in the “ASIC Emulators” group>

5.2 Operating the USB Controller program

Run the USB controller application found on the product CD in
D:\USB_Software_Applications\USBController\USBController.exe
This window will appear showing the current state of the DN9002K10PCI. Next to each FPGA a green light will appear if that FPGA is configured successfully. The above window shows the USB Controller connected to a DN9002K10PCI with two LX330 FPGAs.

5.2.1 Configure an FPGA

Even though the reference design should already be loaded (because you had a CompactFlash card installed when the board powered on), let’s configure an FPGA over USB.

Clear an FPGA of its configuration. Right-click on an FPGA and select from the popup menu, “Clear FPGA”. The blue light above the FPGA on the GUI and on the board should turn off.

To re-configure that FPGA using the USB Controller program, right-click on the FPGA and select Configure FPGA via USB from the popup menu. The program will open a dialog box for
you to select the configuration file to use for configuration. Browse to the provided user’s CD “D:\FPGA_Reference_Designs\Programming_Files\DN9002K10PCI\MainTest\LX330\fpga_a.bit”

If you are configuring an LX220 or LX110 device you should select a bit file from the LX220 or LX110 directories instead. Failing to select the correct type of bit file will result in the USB Controller program to warn you, and the FPGA fail to configure. The program will report the status of the configuration when it finishes. “DONE did not go high”. This refers to the DONE selectMap signal, which is asserted by the FPGA when it is properly configured.

If you are configuring FPGA B or FPGA C, you should select fpga_b.bit or fpga_c.bit instead. Should you configure the wrong FPGA with the wrong bitfile, the FPGA will succeed to configure, but probably won’t function properly. This is not recommended because it could lead to bus contention and excessive heat generation.

The message box below the DN9002K10PCI graphic should display some information about the configuration process. When the configuration is successful, the green LED should re-appear next to the FPGA.

### 5.2.2 Set Clock Frequencies

To change the clock frequencies of G0, G1 or G2, select the “Clock settings” option from the “Settings” menu.

A dialog box appears asking to which frequency you would like to set each clock. Enter 350, 200, 200 for G0, G1 and G2 respectively. The log window will display feedback including what frequencies the clocks were set to. The actual frequency to which each clock is set may differ from the frequency you entered because the frequency synthesizers have a limited granularity.

### 5.2.3 Run Hardware Test (DDR2)

First, hit the “Enable USB->FPGA communication” button. This must be done before the program can interact with the reference design. You must also have the reference design loaded, and a DDR2 module installed in a memory socket connected to the FPGA using that reference design. Also, the clock settings must be correct. Follow the procedure in the previous section to accomplish this.
From the FPGA Memory menu, select Test DDR. A box will appear and ask which FPGA should be tested. The log window will report whether the test passed. If it fails, it will print a list of addresses and data that failed.

If you would like to simulate a failure, you can repeat this guide with the DDR2 module removed. Other tests that could be performed from the USB Controller (but aren't part of this quick-start) are interconnect tests, Ethernet tests, and something else. For information on running these tests, see the Software chapter.

5.3 Getting data to and from the FPGA

The USB Controller program also allows you to easily configure and transfer data to and from the user design on the emulation board. This data transfer occurs over the boards “MainBus”. This interface is described in the Hardware chapter.

Some users may choose not to implement the “MainBus” interface, and use these signals for general-purpose FPGA interconnect. To allow this, by default the main bus is disabled, and the Host interface (USB in this case) is prevented from operating it. To override this setting, hit the “Enable USB->FPGA communication” button near the top of the window.

To read data from the FPGA design (the Dini Group reference design), select from the menu MainBus->Read

In the resulting dialog box, enter the address 0x080000000 in the address box, and “10” in the “number of DWORDs” box. Press OK, and then DONE. The result of the read is printed to the USB Controller log window.

```
FPGA READ
0x080000000 0x00000000
0x080000001 0x05000135
0x080000002 0xDEAD1234
0x080000004 0x1D000000
...
```

Figure 7 USB Controller Log Output

The address 0x080000000 is defined by the “MainBus” interface to be mapped within FPGA A on the DN9002K10PCI. If FPGA A is not loaded with the Dini Group reference design (or a design that implements the MainBus slave), then all address reads will return 0xDEADDEAD.

6 Communicating over the Serial Port

You may want to communicate with your design over the user serial port (P2). The MainTest reference design that you already loaded has an asynchronous loop back on this port. If you want to test this connection, connect an RS232 terminal to the header and type stuff. The port should echo back that very same stuff.
7 Run AETest_wdm

The program provided to access the DN9002K10PCI over PCI is called AETest. It is located on the user CD
D:\PCI_Software_Applications\Aetest\aetest\aetest_wdm.exe

AETestdj.exe must instead be run if you are running DOS
AETest98.exe must instead be used if you are running Windows98. This version is no longer actively supported, and it might not work. Why are you using Windows 98?

If you are running Linux or Solaris, you must compile AETest before continuing this quick-start guide. Details are in the Software Chapter. The rest of this guide assumes you are using Windows XP.

After you turn your computer on the computer will display a dialog asking for the driver for a “Dini Group board with QL5064 PCI”

Click “Choose a driver to install” -> Click “Have Disk” and browse to D:\ PCI_Software_Applications\Aetest\wdmdrv\drv\dndev.inf

7.1.1 Use AETest

The AETest application should display its main menu.

If this window says something like “GUID not found”, then the driver is not installed properly. Check in the windows device manager and see if a device with VID 0x17DF and PID 0x1864 is there.
This is the menu, with some things you can do. I highly recommend the fun-to-use “Production test menu”. You can run the “PCI” test. This will write stuff to the PCI reference design that may or may not be loaded into FPGA A, and report the results.

The “memory” menu is also fun, as it lets you display PCI memory space directly, and also allows access to the “MainBus” interface that we used a little earlier.
Above is an example of a board failing the production test. Ideally, your board would pass the production test instead.

It is acceptable to operate the DN9002K10PCI from USB and PCI at the same time. The mutual exclusivity of all features is not finalized, but it’s a safe bet that if you use the “MainBus” feature from PCI and USB simultaneously, the board will do something other than work properly.
8 Scan the JTAG chain

If you wish, you can program the FPGAs using their JTAG interface. Connect a Xilinx Platform USB cable into the FPGA JTAG port (J7), and open the IMPACT program that is installed with Xilinx ISE 9.1.

When you connect the Platform USB cable for the first time, Windows will automatically install a driver three times in a row, like a retarded parrot.

The program “scans the chain” to auto-detect the type and number of FPGAs installed on your board and display them on the screen. Right click on an FPGA and select “choose configuration file”. Browse to the bit files provided on the user CD

D:\FPGA_Reference_Designs\Programming_Files\DN9002K10PCI\MainTest\LX110\fpga_A.bit

This JTAG port should also be used for visibility products like Xilinx ChipScope.
8.1 Moving On

Congratulations! You have just programmed the DN9002K10PCI and learned all of the features that you have to know to start your emulation project. If you are new to Xilinx FPGA, you might want start by compiling the reference design, and adding code to the reference design, until you are comfortable with the design flow. You should also use the provided UCF constraint file as a starting point for your UCF file.
Chapter 3: Controller Software

The DN9002K10PCI can be hosted from USB or PCI. As an example to hosting using these interfaces, the Dini Group provides some controller software that allows configuring FPGAs, and changing the board settings. For more complex host behavior, such as interactively transferring data to and from the board from the host computer, you may have to develop your own host software, either USB or PCI. At the end of this chapter, there is a programmer’s guide to help you interface to the DN9002K10PCI. This, along with the source code of the example software should be able to get you communicating with the DN9002K10PCI.

The software included with the DN9002K10PCI is

- **USB Controller** – A Windows XP only GUI application capable of configuring FPGAs, sending data to the user FPGA core via USB, changing board settings, and running hardware tests.

- **AETest_usb** - A cross-platform (Windows, DOS, Linux, Solaris) command-line application capable of configuring FPGAs, sending data via USB, and changing board settings.

- **AETest** A cross-platform (Windows XP, Windows98, DOS, Linux, Solaris) command-line program capable of configuring FPGAs, and sending data to and from user FPGA cores via PCI.

These programs and the source code for them can be found on the user CD
D:\PCI_Software_Applications\Aetest\  
D:\USB_Software_Applications\USB_CMD_Line_AETEST_USB\  
D:\USB_Software_Applications\USBController\

Precompiled windows XP binaries for USB Controller, and AETest_usb, and AETest are provided on the user CD as a Microsoft Visual Studio 6 project. Visual Studio 6 or later is required to compile these programs.

All three programs use a driver provided by the Dini Group.

The PCI drivers can be found at  
PCL_Software_Applications\Aetest\wdmdrv
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PCI_Software_Applications\Aetest\linuxdrv
PCI_Software_Applications\Aetest\solaris\driver

The USB driver can be found at
USB_Software_Applications\driver

1 USB Controller

The USB Controller program is intended to
- Verify Configuration Status
- Configure FPGAs over USB
- Configure FPGAs via CompactFlash card
- Clear FPGAs
- Reset FPGAs
- Set Global clocks frequency
- Update firmware (for MCU and Spartan)

The following function interface with the Dini Group reference design.
- Read/Write to FPGAs – see the chapter Reference Design for a description of the Main bus interface.
- Test DDRs/FLASH/Reigsters/FPGA Interconnect

1.1 Main Window

The main USB Controller window has the following components: a menu bar, a refresh button, a “Disable USB” button, and board graphic, and a message log.
Each item in the menu bar is described later in this section.

1.1.1 Refresh Button

The Refresh button updates the board graphic by querying the DN9002K10PCI and reading back its status. The USB Controller program does not poll the board, and only updates the status when there is some user command. Items that may be updated when the refresh button is hit are:
- Type of board connected (DN9002K10PCI in this case)
- Number of FPGAs installed
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- Whether or not the FPGAs are configured (blue DONE LED on/off)
- Whether the Dini Group reference design is loaded in one or more FPGAs (disable/enable the “FPGA Reference Design” menu)
- Check whether USB is enabled

1.1.2 Disable/Enable USB

To communicate to the FPGA design using USB, the “Main Bus” interface is used. See the hardware chapter for more information on this interface. Some users elect not to use the Main Bus for USB communication. To allow these users to make use of the signals in the Main Bus for their own purposes, the USB Controller is careful not to use the Main Bus unless explicitly given permission by the user. The user can give permission to use Main Bus by pressing the “Enable USB->FPGA communication” button. It can revoke that permission by pressing the “Disable USB->FPGA communication” button. When the DN9002K10PCI powers on, it begins in the disabled state. The state is stored on the board, so that multiple programs accessing the DN9002K10PCI may prevent each other from using the Main Bus.

1.1.3 Log Window

This text box prints the result of each user command in USB Controller. There is a “clear log” button to clear the contents of this text box.

1.1.4 Board Graphic

USB Controller’s main window shows a graphic representing your DN9002K10PCI. The number of FPGAs that are installed on your board should appear in this graphic. If one or more FPGAs are configured on the board, a blue LED will glow next to the FPGA in this graphic window, just like on the actual board hardware itself.

If the USB Controller could not find a DN9002K10PCI connected to any USB port, this window will appear.
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If the board is turned on and plugged in, the USB Controller should be able to detect it. If it does not, try opening the Device manager. You can right-click on the “My computer” icon and select “Hardware tab” and click the “Device Manager” button. This will display a list of the devices connected to your computer. If a Dini Group Logic Emulator appears in the USB section, then USB is working properly on the board, but the program is unable to connect to it. Select “Switch Device” from the File menu. If the board does not appear in the Hardware manager, then the DN9002K10PCI may be stuck in reset. See the “Troubleshooting” section in the Hardware chapter. Also, check the red “Reset” LED.

As well as providing visual feedback, the board graphic can be used to control configuration of the FPGAs. To do this, right-click on an FPGA in the graphic to show a contextual menu with the options: Configure, Clear and reconfigure.

Configure will show an Open… dialog for you to select the bit file you wish to use with the FPGA. Clear FPGA will clear and reset the FPGA of its current configuration. Reconfigure FPGA will configure the FPGA with whatever bit file that this instantiation of USB Controller used to configure that FPGA last.

1.2 Menu Options

The following sections describe each menu option and its function.

1.2.1 File Menu

The File Menu has the following 2 options:

a. Open – opens a file with the selected text editor (notepad by default). To change the text editor see Settings/Info Menu section

b. About

Displays USB Controller version number, along with other things.

c. Switch device

Displays a list of all Dini Group USB devices detects and allows the user to switch the “current” device. The USB Controller will behave as if the “current device” is the only attached Dini Group USB product. Under some situations,
the USB Controller may automatically switch device when the “current device” is not valid.

d. Exit – Closes the USBController application

1.2.2 Edit Menu

The Edit Menu performs the basic edit commands on the command log in the bottom half of the USBController window.

Copy, delete, and select all

1.2.3 FPGA Configuration Menu

The FPGA Configuration Menu has the following options:

(1) Configure via USB (individual)

this menu option allows you to configure an FPGA. It is equivalent to selecting an FPGA by clicking on it and selecting “Configure”, except that this menu option will display a dialog asking which FPGA to configure. Before any FPGA is configured in USB Controller, a “sanity check” is performed. This reads the header out of the binary bit file and determines whether the bit file is compatible with the FPGA installed on the DN9002K10PCI. It will prevent configuration if the “sanity check is not passed” This check can be disabled from the “Settings/Info” menu.

(2) Configure via USB (using file)

this command allows the user to configure more than one FPGA over USB at a time. To use this option you must create a setup file that contains information on which FPGA(s) should be configured and what bitfiles should be used for each FPGA. The syntax of this file is similar or identical to the syntax of the CompactFlash main.txt interface. Details are found in the USB Controller manual on the user CD at D:\USB_Software_Applications\USBController\doc\USBController_Manual.pdf

(3) Configure via CompactFlash

this command causes the FPGAs to configure based on the instructions in the main.txt file on the CompactFlash card. It will also cause the commands and settings on the main.txt file to be re-issued.

(4) Clear All FPGAs

this command resets all FPGAs, causing them to lose their configuration.

(5) Reconfigure All FPGAs

this menu command is equivalent to selecting “reconfigure FPGA” in the context menu of each of the FPGAs. Each FPGA is cleared before being configured. The last bit file that was loaded via USB for each FPGA is loaded again into the FPGA. If an FPGA has not been loaded with a bit file using this instance of USB controller, it is skipped.
(6) Reset
this command asserts the RESET# signal to all FPGAs simultaneously. This is the same signal that is asserted when the user hits the “Soft Reset” (User Reset) button. Its function in the user design is left for the user to define. In the reference design, it causes a global, asynchronous reset. This option also causes the SYS_RSTn signal on the daughtercards to be asserted.

1.2.4 FPGA Reference Design
- Single Ended Interconnect Test (slow)
  this menu option will run test single ended test on which FPGA is configured.

- Read FPGA Clock Frequencies
  This menu option measures and reads back the frequencies of the eight global clock networks, and displays them on the message log.

- Read DDR I2C Data
  This menu option read back DDR2 information

1.2.5 Main Bus
The way that user FPGA designs can communicate over USB is the “Main Bus” interface. The “Reference design” menu uses the main bus to read and write registers in the reference design to control the board tests. These tests can be done by the using these menu options without the user having to understand the Main Bus interface or the main bus memory space and it’s mapping to the reference design. The Main Bus menu allows direct control of the Main Bus. This can be useful if you are using your own FPGA core that implements the main bus.

- Write and Read DWORD
  this displays a dialog box for writing and reading to the Main Bus address space. It includes some debugging features. All main bus transactions are of length 4 bytes (DWORD)

- Test Address Space
  This writes and reads random data to the address range specified in a dialog box, and prints and error message when the read and write do not match.

- Read Address Space to file
  this reads data from the main bus at the address specified, and writes the data to a binary file specified. Data on the main bus is in little-endian order. The address after each DWORD is implicitly incremented. This behavior can be turned off (contact support)

- Write Address space from file
  this reads data from a file and writes the data to the address on main bus specified. The data is written in little-endian order. The address is implicitly incremented after each DWORD of data. This behavior can be changed (contact support)
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- Send Command File
  This option reads an ASCII file that can contain both reads and writes. Reads will cause the data to be displayed on the log window. The specification for the format of this file is the one which can be inferred from the example below.
  AD 08000000
  WR 0000FFFF
  WR 000000FF
  AD 08000000
  RD 3
  This example writes 0x0000FFFF to address 0x08000000, 0x000000FF to address 0x08000001, then prints out the contents of addresses 0x08000000 through 0x08000002.

1.2.6 Settings/Info Menu
The Settings/Info Menu has the following options

1. Change Text Editor
   This option changes the behavior or “Open” in the file menu and is otherwise undocumented.

2. FPGA Stuffing information
   displays a list of the FPGAs on the board, and their type and speed grade. This information is stored in the firmware flash, and is not detected on the fly.

3. Board/Spartan/MCU version
   this option is used to read the version number of the current board’s firmware. There are two types of firmware, the “Flash” and the “Prom”. The two types of firmware, the reference design, and the USB Controller application are only guaranteed to work when using corresponding versions of each. If you update one, you should update the others.

4. Read FPGA temperatures
   Displays the current temperature of the on-die FPGA temperature sensors.

5. Force Memory Menu display
   When the Dini Group reference design is not loaded in at least one FPGA, the “FPGA Reference Design” menu is disabled. This menu command causes that menu to be displayed in this situation. The USB Controller determines if the Dini Group reference design is loaded by reading a memory location on Main Bus and comparing the result to a predefined value. This menu may also be disabled because the “USB->FPGA Communication” is disabled.

6. Toggle Sanity Check
   This menu command changes the behavior of configuration where it reads the header in the binary bit file and determines if the file is compatible with the installed FPGA. This may be necessary if using bitstream encryption or using a custom bitfile not created by ISE 8.2 bitgen.
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(7) Setup clock frequencies
this menu option displays a dialog box allowing the three global clock networks to be configured.

(8) Global clock muxes setup
This menu option display a dialog box allowing to select with output for global clocks and External clocks

1.2.7 Production Tests
(1) Test DDR2
this menu option displays a dialog box allowing testing of the DDR2 sockets on the DN9000k10. If the Dini Group reference design is not loaded, the command will automatically load them into the FPGAs. If the clocks are not set, the command will automatically set them to settings compatible with the DN9000k10PCI reference design.

(2) One Shot Test
This menu option contains most of the hardware tests that can be run on your board. The tests that this menu runs work identically to the hardware tests that your board passes before shipping. There are some options available in the settings dialog window.
- **Main One Shot Test:** contains interconnect, main bus, clock, pull-ups
- **DDRs Test:** Tests DIMMA and DIMMB connections. You must have a DDR2 SODIMM installed in each socket before the test is run.
- **Headers Test:** You should uncheck this box. It will fail without a test fixture.
- **Ethernet Test:** You should uncheck this box. It requires a test fixture.
- **External clocks test:** This test requires a test fixture.
- **Test FPGA Q:** This will test interconnect between FPGA A and FPGA Q
- **LVDS Frequency:** This is the frequency that the FPGA-to-FPGA interconnects will run during the test. 450 is the standard test frequency.
- **Bitfile Path:** This is where the program will get the reference design bit files. They were on the provided user CD.
- **Iterations Count:** The number of consecutive times the entire test will run

1.2.8 Service Menu
Please contact Dini Group to enable this menu.

1.3 INI File
Some command considered “debugging” commands save persistence information in an “ini” file that gets created in the same directory as the USB Controller executable. This file should not be generated for most users. If it is generated, you can safely delete it, unless you like it. Some of the settings that can be stored in this file are the Text Editor Selection settings, the location of (path to) the reference design programming files (for one-shot-test), and enabling the debug menu.
2 AETest USB

The command line USB controller program is called “AETEST_USB”. It provides a subset of the features available on USB Controller and is cross platform. This program is a convenient place to start if you are going to be writing a custom IO controller for USB to communicate with the DN9002K10PCI

2.1 Compiling AETest_usb

AETest_usb can be compiled using Microsoft Visual Studio 6 or later, or on any version of Linux that supports the usbdevfs library.

A make file is provided, but you must un-comment one of the following lines to define which operating system you are running. In Windows, you should run nmake.

```bash
#DESTOS = WIN_WDM
#DESTOS = LINUX
#DESTOS = SOLARIS
```

2.2 Compiling the Driver

Compiling the driver on windows requires the windows driver development kit. A script “Makeit.bat” can be run from within the windows DDK build environment.

Most people don’t need to compile the driver in windows because it already works.

In Linux, the driver must be compiled unless you happen to be using the same architecture and OS version as ours when we compiled it.

3 PCI AETEST Application

AETEST utility program can test and verify the functionality of the DN9002K10PCI Logic Emulation board, and provide data transfer to and from the User design.

All AETEST source code is included on the CD-ROM shipped with your DN9002K10PCI Logic Emulation kit. AETEST can be installed on a variety of operating systems, including:

- DOS and Windows 95/98/ME using DPMI (DOS Protected Mode Interface)
- Windows 98/ME using a VxD driver
- Windows 2000/XP (Windows WDM)
- Windows NT
- Linux
- Solaris
3.1 Functionality
The AETEST utility program contains the following tests:

- PCI Test
- DDR2 Memory Test
- Flash Test
- Daughter Card Test

AETEST also provides the user with the following abilities:

- Recognize the DN9002K10PCI
- Display Vendor and Device ID
- Set PCI Device and Function Number
- Display all configured PCI devices
- Various loops for PCI device-function and ID numbers
- Write and Read Configuration DWORD
- Write DWORD, Read DWORD and Write/Read DWORD (Same Address)
- BAR Memory Fill, Write and Display
- Configure/Save BARs from/to a file

3.2 Running AETEST
The following images show a terminal session in Windows XP.

The initial display of AETest shows the results of its scan of the PCI bus. If the driver for the DN9002K10PCI is not installed, then the software will display a message that no device was found.
CONTROLLER SOFTWARE

So many options.

Here is the board failing the PCI test.

3.3 Compiling AETEST (PCI)

3.3.1 Compiling AETest for DOS
The DOS version of AETest requires DJGPP. You can find it at http://www.delorie.com/djgpp/
Follow the installation instructions for DJGPP. The download comes with a utility to set your environment variables correctly.
D:\AETest\aetest
Contains the source code for AETest. Copy this directory to your hard drive. Open the file
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Make file. This file must be edited to define which operating system you wish to target.
Uncomment the line
#DESTOS = DOS_DJGPP
and the line
include Makefile.make

In a DOS shell, run make

3.3.2 Compiling AETest for Windows XP
AETest for Windows requires visual studio 6 or later to compile.

Open the provided make file and uncomment the lines
#DESTOS = WIN_WDM
Run nmake.

4 Rolling Your Own Software

Most customers who need to use USB or PCI as a data interface to their FPGA designs write
their own USB and PCI controller programs, since the USBController and AETest programs do
not meet their requirements.

4.1 USB
The behavior of the DN9002K10PCI with regard to the USB interface is given in the Hardware
chapter.

4.2 PCI
The host software requirements to interface with the DN9002K10PCI over PCI are given in the
Hardware chapter.

5 Updating the Firmware

Dini Group may release firmware bug fixes or added features to the DN9002K10PCI. If a
firmware update is released you will need to download this new code to the firmware flash of
the DN9002K10PCI. There are three firmware files that Dini Group may release:
EEPROM_FLP.iic for EEPROM; firmware.hex for FLASH and prom_flp.mcs for Spartan
PROM

The first firmware update is for EEPROM, which stands for Electrically Erasable
Programmable Read-Only Memory. The Firmware Mode is booted from here. This firmware is
rarely changed. Please consult with us before updating this device.

The second firmware update is Micro Controller (MCU) software that is stored in a flash
memory. The User Mode is booted from here. This update can be accomplished easily from the
USBController or AEtest_USB application.
The third update that may be required is a Spartan FPGA core update. The configuration data for the Spartan FPGA is contained in a Xilinx configuration PROM. This update can be accomplished with the Xilinx JTAG programming or iMPACT programs. This update requires a Xilinx JTAG cable. Either the Xilinx Platform cable USB ($199) or the Xilinx Parallel cable IV ($125) is appropriate.

If you don’t have Xilinx cable and wish to update Spartan prom, you can use USBController or AEtest_USB to program it through USB. You have to contact us for *.xsvf file.

When updating the firmware, the “Flash”, “PROM” and USBController.exe should all is updated simultaneously, since Dini Group only verifies this code using corresponding versions of each.

5.1 Obtaining the updates
The firmware update files are not posted on the web site. In order to obtain them, you must request them from support@dinigroup.com. You may be required to perform a firmware update to your board to receive support and some features. When updating firmware, you should update in the following order:
1) USB Controller.exe (http://www.dinigroup.com/product/common/USBController.zip)
2) Configuration FPGA PROM firmware
3) EEPROM (option)
4) MCU Flash

5.2 Updating the Spartan (PROM) firmware
5.2.1 Using JTAG cable (Xilinx products)
Connect a Xilinx Platform USB configuration cable to your computer. When the cable is working properly, but not connected to a JTAG chain, the LED on the cable turns amber. When connected to the DN9002K10PCI, the LED turns green.

Connect the cable to the “Firmware” header, J10

Figure 8 Firmware Update Header
Power on the DN9002K10PCI. When the Platform USB cable is connected to a header, the status light turns green.

Open the Xilinx program Impact, usually found at Start->Programs->Xilinx->ISE->Accessories->impact

iMPACT Project Dialog will appear, please hit Cancel.

Choose the menu option File->Initialize Chain.

Impact should detect 2 devices in the JTAG chain: XC3S1000 and XC18V04. For each item in the chain Impact will direct you to select a programming file for each. For the XC3S1000, Press Bypass. Impact will then ask for a programming file to program the XC18V04 device, select the Spartan Firmware update file provided by Dini Group. This file should be named “prom_flp.mcs”. Hit Open.
To program the prom, Right-click on the prom and select Program… from the popup menu. In the options dialog that follows, the options “Erase before programming” should be selected, and “Verify” should be selected. Press OK. The programming process takes an agonizing 35 seconds over the parallel port, or a joyful 5 seconds over USB.
Power cycle the DN9002K10PCI. The new firmware is now loaded. You can close impact and disconnect the Xilinx JTAG cable.

### 5.2.2 Using USBController

If you do not have a JTAG cable, you will need to use the following instructions to update your “Spartan PROM” firmware. This update is dependent on USBController and Flash firmware version. Please double check with us (support@dinigroup.com) to make sure that your current version (MCU version, USBController) supports this option and request *.xsvf file from us.

1. Open USBController.ini and add the line “service_mode=1”. You save and close the file.
2. Launch USBController, go to “Service” menu and select “Program/Update Spartan”. A warning message will appear to ensure that you want to update Spartan. If you do, hit “Yes” button.
3. Open file Dialog will appear. Please select the *.xsvf file that we provide you.
4. After selecting file, there will be debug level dialog. Please select debug level: 0
5. The process takes about 10-15 minutes, please leave the board and USBController alone. The process bar is on the bottom of USBController window.
6. When the execution is finished, power cycle the board.

### 5.2.3 Using AEtest_USB

If you do not have a JTAG cable, you will need to use the following instructions to update your “Spartan PROM” firmware. This update is depending on AEtest_USB and Flash firmware version. Please double check with us (support@dinigroup.com) to make sure that your current version (MCU version, AEtest_USB) supports this option and request *.xsvf file from us.

1. Run aeusb_wdm.exe (or aeusb_linux).
2. At the main menu, please select option 3 “FPGA Configuration Menu”
3. In “Flash Boot Menu”, please select option ‘9’. Note: the option menu is not displayed for security purpose.
4. Please enter the full path filename for the *.xsvf file.
5. Verbose level is ‘0’. The higher verbose level, the slower the program runs.
6. The progress will start from 0 to 100%. This will take long time to complete (10 minutes). Please do not disturb the process.

7. Power cycle the board when finish.

You can also use commend line: “aeusb_wdm_cmd.exe -XSVF <filename.xsvf>” (or “aeusb_linux_cmd.exe -XSVF <filename.xsvf>”).

5.3 Updating EEPROM firmware (not recommend)
To protect against accidental erasure, the EEPROM firmware cannot be updated unless the board is put in firmware update mode during power-on. Find Switch S2 (“User Reset”) on the DN9002K10PCI.
Hold down the “User reset” button while the DN9002K10PCI powers on. Or alternately, while holding down the “User reset” switch, press the “Hard reset” button. The DN9002K10PCI samples the user-reset button on power on to enter into firmware update mode.

5.3.1 Using USBCcontroller
1. Put the board into Firmware Mode (see 5.3)
2. Open USBCcontroller.ini and add this line “service_mode=1”, save and close the file.
3. Run USBCcontroller. “Update Flash” dialog will appear, please select “NO” because we are doing update EEPROM.
4. Go to “Service” menu, select “Program EEPROM”. This Process will take about 1 minute. Please hit OK.
5. Select file EEPROM_FLP.iic. When USBCcontroller completes the update, please power cycle power the board.

5.3.2 Using AETest_USB
1. Put the board into Firmware Mode (See 5.3)
2. Run aeusb_wdm (aeusb_linux). Select option 3 “Firmware Menu”.
3. In EEPROM Boot Menu, please select option 1 “Update EEPROM from <filename>.iic file”.
4. Enter filename (full path). The process should take about 2 minutes.
5. Please power cycle the board.

You can also run this on the command line: aeusb_wdm_cmd.exe -EEPROM <filename.iic>

5.4 Updating the MCU (Flash) firmware
To protect against accidental erasure, the MCU (Flash) firmware cannot be updated unless the board is put in Firmware Mode during power-on (see 5.3). You can either use USBController or AEtest_USB program to update MCU (Flash) firmware.

5.4.1 Using USBController
1. Put the board into Firmware Mode (see 5.3)
2. Run USBController.exe, Flash Update dialog will appear, please select “Yes”.
3. Please select firmware.hex (we provide you this file).
4. When finish, please recycle power the board or hit “Hard Reset” (S3) on the board to boot from User Mode.

5.4.2 Using AEtest_USB
1. Put the board into Firmware Mode (See 5.3)
2. Run aeusb_wdm. Select option 3 “Firmware Menu”.
3. Please select option 2 “Update Flash from <firmware>.hex”
4. Enter the full path filename. It should be firmware.hex that we provide you.
5. The process will take about 2 minutes. When it finishes, please hit “Hard Reset” (S3) on the board or recycle power the board so that DN9002k10PCI can boot from User Mode.

You can also run this on the commend line: “aeusb_wdm_cmd.exe -FLASH <filename.hex>” (aeusb_linux_cmd.exe -FLASH <filename.hex>).

![Figure 13 aeusb_wdm window](image-url)
Chapter 4

Hardware

1 General Overview

The DN9002K10PCI ASIC emulation platform is optimized for providing the maximum amount of interconnect between the Virtex-5 FPGAs. It is the highest-density off-the-shelf development board using the Xilinx Virtex-5 FPGA.

Below is a block diagram of the DN9002K10PCI.
1.1 Marketing Crap

The following is the advertised feature list of this board. This manual is responsible for providing the information necessary to use these features.

1.1.1 Features

- Prototyping system with one or two Xilinx Virtex-5 FPGAs
  XC5VLX110, XC5VLX220, or XC5VLX330 (1760-pin package)

- 100% FPGA resources available for user application:
  - PCI core not required for PCI use
  - Configuration and clocks are controlled off-FPGA
    DDR2 and Ethernet do require FPGA cores.

- 66MHz, 64-Bit PCI bus capable of full PCI bandwidth to and from the FPGAs
  (Full Bandwidth requires LX330 in FPGA A position)

- Nearly 4M ASIC gates (LSI measure) with 2 LX330s

- FPGA-to-FPGA interconnect is single-ended or LVDS
  up to 800Mbs.

- DDR2 SODIMM slot
  Connects to FPGA B
  64-bit data width, 200MHz operation
  DDR2 modules: PC2-3200/PC2-4200
  4GB maximum density per SODIMM (when available)
  aggregate data transfer rate: 3.2GB/s

- Nine board-level global clock networks (G0, G1, G2, MB48, EXT0, EXT1,P75,FBA,FBB)
  Three separate programmable synthesizers (configurable via CompactFlash, USB, PCI)
  Global clocks networks distributed differentially and balanced
  Two single-step clocks
  Four external differential clock inputs. (Two daughtercard and two SMA cables)

- Flexible customization via daughter cards
  Two 400-pin Meg-Array connectors (FCI)
  One connected to FPGA A, one to FPGA B
  93 LVDS pairs + clocks (or 186 single-ended)
  Some Daughtercard signals require LX330 devices
  400MHz (DDR so 800Mbs) on all signal pairs
  Supported IO Voltages: 1.5V, 1.8V, 2.5V, 3.3V
  Power-over-header
HARDWARE

- Built-in FPGA configuration
  Compact Flash, PCI, USB, JTAG
  Configuration
  Readback supported

- One tri-mode Ethernet interface (FPGA B)

- RS232, Logic Analyzer, LEDs.
  Support

1.1.2 Description
The DN9002K10PCI is a complete logic emulation system that enables ASIC or IP designers a vehicle to prototype logic and memory designs for a fraction of the cost of existing solutions. The DN9002K10PCI is hosted on a 32/64-bit, 33/66MHz PCI bus, or can be used stand-alone and configured via USB. A single DN9002K10PCI configured with two Xilinx Virtex-5, XC5VLX330s can emulate up to 4 million gates of logic as measured by LSI (or at least how LSI used to measure ASIC gates when they manufactured ASICs). This number does not include the embedded memories and multipliers resident in each FPGA, all of which are 100% available to user application. The DN9002K10PCI achieves high gate density and allows for fast target clock frequencies by utilizing FPGAs from Xilinx's Virtex-5 FPGA family for logic and memory. All FPGA resources are available for the target application. Any subset of FPGAs can be stuffed.

The DN9002K10PCI uses high I/O-count, 1760-pin, flip-chip BGA packages. Abundant fixed interconnects (either differential or single-ended) are provided between the FPGAs. All pins of all banks of each FPGA are utilized. FPGA to FPGA busses are routed and tested LVDS, run at 400MHz+ but can be used single-ended at a reduced speed. Example designs utilizing the integrated ISERDES/OSERDES with DDR for pin multiplexing are included.

Two separate 400-pin FCI MEG-Array connectors allow for customization with daughter cards. Signals to/from these cards are routed differentially, and can run at the limit of the FPGA: 400MHz. Clocks, resets, and presence detection, along with abundant power are included in each connector.

One DDR2 SODIMM sockets are stuffed and have connections to both FPGAs. Each socket is tested to 250MHz with a DDR2 SODIMM. Standard, off-the-shelf DDR2 memory Dims (PC2-3200/PC2-4200) work nicely and we can provide these for a small charge. We have developed alternative SODIMMs that can be stuffed into these positions. Consult the factory for more details, but the list includes FLASH, SSRAM, QDR SSRAM, Micron and others.

The configuration bit files for the FPGAs are copied onto a CompactFlash card (provided) and an on-board Cypress microprocessor controls the FPGA configuration process. FPGA configuration can also be controlled via the USB interface. Visibility into the configuration process is enhanced with an RS232 port. Sanity checks are performed automatically on the configuration bit files, streamlining the configuration process. FPGA configuration occurs at the
fastest possible SelectMap frequency - 48MHz. Multiple LED's provide instant status and operational feedback.

As always, reference material such as a DDR SDRAM controller, code is included (in Verilog, VHDL) at no additional cost.

2 Virtex 5

The DN9002K10PCI allows use of each of the new features of the Virtex-5 FPGA. As well as exercises all of the external interfaces on the DN9002K10PCI, the included reference design also exercises all of the new (Compared to Virtex 4) Virtex-5 features listed below.

- Greater speed logic and internal routing speed
- Built-in PLLs  
  Example PLL usage found in the DDR2 reference design
- 1.25 Gbs maximum IO speed  
  LVDS design uses high-speed IO **(800Mbs currently)**
- ODELAY output signal delay elements  
  LVDS design dynamically adjusts IDELAY to account for interfaces on the DN9002K10PCI where signals are not externally length-matched (FPGA interconnect)
- 6-input lookup tables
- Larger total-density parts (in terms of total LUT gates)
- More flexible IO

3 Configuration Section

Many functions on the DN9002K10PCI are done by circuitry on the DN9002K10PCI external to the FPGA. Collectively, these circuits are referred to in this document as the “Configuration Section”. The configuration section takes care of:

CompactFlash interface  
USB interface  
PCI interface  
“Main Bus” interface master  
Temperature sensing  
Over/under voltage sensing  
Clock frequency and source configuration  
SelectMap configuration interface  
Blinking red and green LEDs

The Configuration Section is built around a Spartan 3 FPGA and Cypress microprocessor. These ICs are used by the configuration circuit and are not intended for user design. The code running these controlling ICs is collectively referred to as the “firmware”. The code for this firmware is provided, for reasons I don’t know. Customer development efforts on these
platforms is not supported. If you need special configuration circuit behavior, please contact Dini Group and request that we implement it and support it as a standard feature. The technical details of the configuration circuit are omitted from this manual, since the user should not require it.

3.1 Configuration Section Feedback

During normal operation, and in error situations, the configuration section prints messages to the RS232 terminal header. The configuration section processes that can be monitored using this header are:

Temperature sensor: FPGA overheat
CompactFlash card reading
USB configuration
PCI configuration
Main Bus reads/writes
Global clock settings

---

---
The configuration section RS232 terminal header, labeled “MCU” above, can be connected to a computer serial port, using the settings:

19200 Baud  
No flow control  
One stop bits  
No parity

The syntax and content of the output messages changes are not given because they change rapidly. This interface is not at all fun to use, and is intended mostly for Dini Group to debug hardware or software failures.

3.2 FPGA Configuration

Normally, configuration of the Virtex-5 FPGA occurs over the Virtex-5 “SelectMap” interface. The only configuration method possible on the DN9002K10PCI that does not use this interface is JTAG. For a description of the SelectMap interface, see the Virtex-5 configuration guide.

The signals in the SelectMap bus are listed below

D[15:0] SelectMap data signals. (DN9002K10PCI may only use [7:0])

PROGRAM_B Active low asynchronous reset to the configuration logic. This will cause the FPGA to become un-configured. This documentation refers to this signal as PROG#

DONE After the FPGA is configured, it is driven high, or tri-stated by the FPGA.

INIT Low indicates that the FPGA configuration memory is cleared. After configuration, this could indicate an error.

RDWR_B Active low write enable. This Documentation refers to this signal as RDWR#

BUSY This signal is not used by the DN9002K10PCI

CS_B SelectMap chip select. This documentation refers to this signal as CS#

CCLK Clock driven to the FPGA by the configuration section. The SelectMap signals D[15:0], RDWR_B and CS_B synchronous to CCLK

USB, CompactFlash and PCI configuration occur over the SelectMap bus. The configuration section makes no modification of the “bit stream” sent to it over PCI or USB. It only copies the data to the SelectMap interface. The “bit stream” must contain all of the SelectMap commands necessary to configure and startup the FPGA. These SelectMap commands are created automatically by Xilinx tool bitgen (part of ISE). Not all of the bitstream generation options available in bitgen are compatible with the DN9002K10PCI:
Currently, before configuring the FPGA using any method (except JTAG), the configuration section asserts the PROG# signal of the FPGA to clear it. For this reason, the “disable SelectMap” option in bitgen has no effect.

On each FPGA, the DONE signal is connected to a blue LED located next to each FPGA. This signal gives a quick indication of whether each FPGA is configured or not.

The data signals, D[15-0] are dual-purpose signals and can be used as additional interconnect pins after all FPGAs have been configured. Care must be taken that the FPGA design does not drive these signals until after all FPGAs have been configured. The configuration section will assert the FPGA_RESET# signal until this occurs (CompactFlash configuration only). If you do use the SelectMap data signals as interconnect, the provided software (USB Controller) is not guaranteed to function properly (may interfere with your design). When using these signals as interconnect, the appropriate drive standard is LVCMOS25. The IO voltage is 2.5V.

SelectMap Readback is possible on the DN9002K10PCI. This can be accomplished over PCI or USB. The user interface for obtaining this data is not defined. If you need this feature contact the Dini Group.

The JTAG configuration method does not go through the configuration circuit. See the JTAG interface section for details about this.

### 3.3 USB and PCI interfaces

The USB and PCI interfaces can be used for both configuration (FPGA configuration, and clock settings, etc.) or for direct communication with the user design in the FPGA. These interfaces are described individually in their own sections in the hardware chapter.

### 3.4 CompactFlash Interface

Most important settings on the DN9002K10PCI can be controller through the Compact Flash interface. This interface can also be used to configure FPGAs. The CompactFlash interface is not under the direct control of the user, but is accessed only by the configuration logic.
3.4.1 Main.txt

The main.txt interface is the primary method you will use to control settings on the DN9002K10PCI. From this interface, you can

- Configure FPGAs
- Set clock frequencies
- Write to MainBus

Other settings on the DN9002K10PCI can also be controlled via the main.txt file by accessing the configuration registers, using the MEMORY MAPPED command.

To use the main.txt interface, create a file called main.txt on the root directory of the Compact Flash card. Plug the card into the DN9002K10PCI. The DN9002K10PCI will execute commands contained within this file when the board powers on, when the Hard Reset button is pressed, or when instructed to do so by the USB interface (vendor request).

A main.txt file contains a list of commands, separated by newline characters. A list of valid main.txt commands is given below.
HARDWARE

// <comment>
FPGA A:<filename>
FPGA B:<filename>
CLOCK FREQUENCY: 0 <number> [MHz]
CLOCK FREQUENCY: 1 <number> [MHz]
CLOCK FREQUENCY: 2 <number> [MHz]
SANITY CHECK: <yn>
VERBOSE LEVEL: <level>
MEMORY MAPPED: 0x<SHORTADDR> 0x<BYTE>
MAIN BUS 0x<WORDADDR> 0x<WORDDATA>

<comment> can be any string of characters except for newline.
<filename> can be the name of a file on the root directory of the CompactFlash Card.
<yn> can be any positive number in decimal. Decimal points are allowed.
<level> can be 0,1,2 or 3
<SHORTADDR> is a 2-digit number in hexadecimal (16 bits)
<BYTE> is a 1-digit number in hexadecimal (8 bits)
<WORDADDR> 4-digit (32 bit) number in hexadecimal representing a main bus address
<WORDDATA> 4-digit (32 bit) number in hexadecimal containing data for a main bus transaction

The following table describes the function of each of the available main.txt commands.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>// &lt;comment&gt;</td>
<td>The configuration circuitry performs no operation and moves to the next command.</td>
</tr>
<tr>
<td>VERBOSE LEVEL: &lt;level&gt;</td>
<td>This command will set the amount of output that will be produced over the RS232 port during configuration. When level is set to 0, the port will produce only error output.</td>
</tr>
<tr>
<td>FPGA A:&lt;filename&gt;</td>
<td>The Virtex 5 FPGA “A” will be configured with the file named by &lt;filename&gt;</td>
</tr>
<tr>
<td>FPGA B:&lt;filename&gt;</td>
<td>The Virtex 5 FPGA “B” will be configured with the file named by &lt;filename&gt;</td>
</tr>
</tbody>
</table>
### HARDWARE

| SANITY CHECK: <yn> | If <yn> is set to y, then the MCU will examine the headers in the .bit files on the CompactFlash card before using them to configure each FPGA. If the target FPGA annotated in the .bit file header is not the same type as the FPGA the MCU detects on the board, it will reject the file and flash the error LED.

Before this command is executed, <yn> is set to the default value y.

If you want to encrypt or compress your bit files, you will need to set <yn> to n.

| MAIN BUS 0x<WORDADDR> 0x<WORDDATA> | Writes data in <WORDDATA> to the address on the main bus interface at <WORDADDR>. This command only makes sense in the context of the Dini Group reference design, unless your design implements a compatible controller on the main bus pins. The Specification for this interface is in MainBus section.

| MEMORY MAPPED: 0x<SHORTADDR> 0x<BYTE> | Writes to a configuration Register. This command can be used to access features that do not have a main.txt command. Example applications include setting clock sources, setting the EXT0 or EXT1 clock buffers to zero-delay mode, or setting the clocks to frequencies lower than 31Mhz.

| CLOCK FREQUENCY: <clockname> <number> MHz | The MCU will adjust the clock synthesizer producing clock <clockname> to the frequency <number>. Currently, only frequency settings from 31Mhz to 700Mhz are supported. Contact support@dinigroup.com for frequencies from 2 to 31Mhz.

An example main.txt file is given below.

```
VERBOSE LEVEL: 0
// This will prevent the MCU output over RS232 to speed up configuration
FPGA A:a.bit
//this will load the configuration a.bit into FPGA A
CLOCK FREQUENCY: G0 300Mhz
MAIN BUS: 0x08000000 0x00000001
//Writes to a register in FPGA A.
```

Even if you are not planning to configure your Virtex 5 FPGAs using a CompactFlash card, you may want to leave a CompactFlash card in the socket to automatically program your global clock. (Clocks may also be programmed using the provided USB application, or over the PCI bus.)
Some of the current limitations of the main.txt interface are given here. Directories are not supported for FPGA configuration files. All bit files must be contained in the root directory of the card. File name lengths for bit files are limited to 8 characters. You can still use bit files with longer file names by specifying the DOS version of the file name in the main.txt file. For example, to configure FPGA A with the file

Com_apple_sj45_ethn0_fpga_b_121107b.bit

You can use the main.txt command

FPGA A: com_ap~1.bit

3.4.2 Hardware
The Compact Flash interface is hot-swappable.

An activity LED, DS147, located next to the Compact Flash slot indicates activity on this interface.

Due to a flaw in the software design, some Compact Flash cards may be incompatible with the DN9002K10PCI. Please contact support@dinigroup.com if you find an incompatible card, so that we can add software support for it.

Also, the board only accepts CompactFlash cards formatted in the FAT file system. Most newer compact flash cards come pre-formatted with the FAT32 file system. In this case, the DN9002K10PCI will not be able to recognize files on the card.

3.5 Configuration Registers
The configuration control on the DN9002K10PCI is controlled by setting “configuration registers”. Basically, these are just locations in the memory space of the on-board micro controller that controls the board’s function. A full description of the function of this micro controller is omitted, but some of the registers in this space are required to be accessed over USB or PCI to control the board. For information on how to access this address space over USB or PCI, see the corresponding section in this chapter.

<table>
<thead>
<tr>
<th>REGISTER</th>
<th>ADDRESS</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPGA_RESET</td>
<td>DF22</td>
<td>Write 0x2 to hold reset. 0x0 to release</td>
</tr>
<tr>
<td>G0_N_VAL</td>
<td>DF29</td>
<td>Sets the divider value of G0</td>
</tr>
<tr>
<td>G0_M_VAL</td>
<td>DF30</td>
<td>Sets the 8442 multiplier of G0</td>
</tr>
<tr>
<td>G1_N_VAL</td>
<td>DF31</td>
<td>Sets the 8442 divider value of G1</td>
</tr>
<tr>
<td>G0_M_VAL</td>
<td>DF32</td>
<td>Sets the 8442 multiplier of G1</td>
</tr>
<tr>
<td>G2_N_VAL</td>
<td>DF33</td>
<td>Sets the 8442 divider value of G2</td>
</tr>
<tr>
<td>G2_M_VAL</td>
<td>DF34</td>
<td>Sets the 8442 multiplier of G2</td>
</tr>
<tr>
<td>UPDATE_CLOCK_FLAG</td>
<td>DF40</td>
<td>When high, each bit causes the configuration circuit to update the represented clock frequency with the current M and N values. 0x01 is G0, 0x02 is G1, 0x04 is G2</td>
</tr>
</tbody>
</table>
FPGA_COMMUNICATION DF39 Disables Main Bus interface
TEMP_SENSOR_A DF50 Temperature of FPGA A
TEMP_SENSOR_B DF51 Temperature of FPGA B
SERIAL_NUMBER DFFA
BOARD_TYPE DFFE

3.5.1 Undocumented controls
Most of the accessible registers to control board function (used by the AETest_usb and USB Controller programs) are not documented in the table above. This is because we do not anticipate a need for customer use. If there are board features that are accessible through USB Controller or AETEST programs that you feel you need access to in your own PCI or USB applications, contact support@dinigroup.com and we will provide details on using the interface you require. A list of these features is provided below

G0, G1, G2 frequencies below 31 MHz
Single-step clocking on G0, G1, G2 clock networks.
Zero-Delay Daughtercard clock network
External clock source selection
Readback of G0, G1, G2 frequency measurements
MainBus error counter

3.6 Firmware
A Spartan 3 FPGA and a Cypress micro controller control the configuration circuitry. The programming data for the FPGA is stored on a flash device, and the code for the micro controller is stored on a separate flash device. The instructions for updating the firmware are given in the software section. The flash that stores the Spartan FPGA programming information is made available via a JTAG header, which can be used with the Xilinx program impact. The Dini Group does not recommend doing any sort of development on this FPGA, because if you add custom code, you will not be able to use firmware updates from Dini Group without merging it with your custom code.
4 Clock Network

4.1.1 GC Pins
When this manual refers to a “clock input” of an FPGA, it means the “GC” pin described in the Virtex-5 user manual. These pins have the capability of driving a DCM, PLL, or BUFG input with a known (accounted for) delay within the FPGA.

4.2 Global Clocks
All of the “global clock networks” on the DN9002K10PCI are LVDS, point-to-point signals. The arrival times of the clock edges at each FPGA are phase-aligned (length-matched on the PCB) within about 100ps. These clocks are all suitable for synchronous communication among FPGAs.

Since LVDS is a very low voltage-swing differential signal, you cannot receive these signals without using a differential input buffer. Single-ended inputs will not work. An example Verilog implementation of a differential clock input is given below.

Wire aclk_ibufds;
IBUFGDS G0CLK_IBUFG (.O(g0clk_ibufg), .I(GCLK0p), .IB(GCLK0n)) ;
always@(g0clk_ibufg) begin
   // Registers
end

Either in the UCF or using a synthesis directive, you should turn the DIFF_TERM attribute of the IBUFGDS to TRUE. This is recommended because there are no external termination resistors on the DN9002K10PCI.

All global clock networks have a differential test point. The positive side of the differential signal is connected to pin 1 (square) and the negative side is connected to pin 2 (circular).
A diagram of the global clock network is shown above. Each of the eight clock outputs of the clock network is distributed to both FPGAs.

### 4.3 G0, G1, G2 Clocks

The G0, G1 and G2 clocks are the primary clock resource for your FPGA design. Each of these clocks can be set to a wide range of frequencies between 2 and 550 MHz.

On the schematic, these signals are named 

```plaintext
CLK_G*_p
```

where * is 0,1 or 2 and * is the name of the FPGA connected to that signal.

The possible source of G0 and G1 clock is either the ICS8442 frequency synthesizer or a “step clock”. The “step clock” is driven by the configuration circuit and can be toggled over USB or PCI by writing to the correct configuration register. 0xDF23[2], 0xDF23[1]. Before the Synthesizer or step clock drives the network, the correct source setting must be made in the GUI or in the main.txt file. By default the source is the synthesizer.

The syntax to set the clock source in the main.txt file is

(contact support@dinigroup.com. This setting does not exist yet)

In USB Controller, from the settings menu, select DN9002K10PCI clock source settings
HARDWARE

The possible sources of the G2 clock are the synthesizer, or FPGA A (using the CLK_FBA_INT signal. FPGA drives this 3.3V, LVCMOS clock signal. From the USB Controller program you can select CLK_FBA_INT from the settings->DN9002K10PCI clock source dialog. This setting can also be achieved over PCI or USB, but the interface is not documented here, so you must contact support if you require this function.

4.3.1 Clock Synthesizers
The G0, G1, and G2 clock synthesis source is driven by an ICS8442 clock synthesizer chip. This chip is capable of driving a wide range of output frequencies. If you use the USB Controller, CompactFlash card, or AETest program to set the clocks, you do not need to understand how the 8442 synthesizer works. The interface for USB and PCI to set the synthesizer frequencies directly controls the PLL unit within the ICS8442 synthesizer. The PLL only accepts a limited range of inputs. If you are creating your own USB or PCI software, you need to read the 8442 datasheet provided on the user CD.

In summary, the multiplication and division factors of the synthesizer need to be set.

Note that frequencies below 31.25Mhz are achieved by using the PLL_SEL input to the synthesizer chips to disable the frequency multiplication.

4.3.2 Possible Outputs
Only some multiplication and division settings are possible on the clock synthesizers described above. (The synthesizer can only do integer multiplication, and power-of-two division).

Limited resolution. When you use USB Controller to set a global clock frequency on the DN9002K10PCI, it automatically selects the closest frequency possible from the following lists.

G0, synthesized from a 25.0 MHz crystal
3.13, 6.25, 12.50, 25.00, 31.25, 34.38, 37.50, 40.63, 43.75, 46.88, 50.00, 53.13, 56.25, 59.38, 62.50, 65.63, 68.75, 71.88, 75.00, 78.13, 81.25, 84.38, 87.50, 93.75, 100.00, 106.25, 112.50, 118.75, 125.00, 131.25, 137.50, 143.75, 150.00, 156.25, 162.50, 168.75, 175.00, 187.50, 200.00, 212.50, 225.00, 237.50, 250.00, 262.50, 275.00, 287.50, 300.00, 312.50, 325.00, 337.50, 350.00, 375.00, 400.00, 425.00, 450.00, 475.00, 500.00, 525.00, 550.00

G1, Synthesized from a 14.318 MHz crystal
1.79, 3.58, 7.16, 14.32, 32.22, 34.01, 35.80, 37.58, 39.37, 41.16, 42.95, 44.74, 46.53, 48.32, 50.11, 51.90, 53.69, 55.48, 57.27, 59.06, 60.85, 62.64, 64.43, 66.22, 68.01, 69.80, 71.59, 73.38, 75.17, 76.96, 78.75, 80.54, 82.33, 84.12, 85.91, 89.49, 93.07, 96.65, 100.23, 103.81, 107.39, 110.96, 114.54, 118.12, 121.70, 125.28, 128.86, 132.44, 136.02, 139.60, 143.18, 146.76, 150.34, 153.92, 157.50, 161.08, 164.66, 168.24, 171.82, 175.40, 178.98, 182.56, 186.13, 193.29, 200.45, 207.61, 214.77, 221.93, 229.09, 236.25, 243.41, 250.57, 257.72, 264.88, 272.04, 279.20, 286.36, 293.52, 300.68, 307.84, 315.00, 322.16, 329.31, 336.47, 343.63, 350.79, 372.27, 386.59, 400.90, 415.22, 429.54, 443.86, 458.18, 472.49, 486.81, 501.13, 515.45, 529.77, 544.08
HARDWARE

G2, Synthesized from a 16.0 MHz crystal

2.00, 4.00, 8.00, 16.00, 32.00, 64.00, 128.00, 256.00, 512.00, 1024.00, 2048.00, 4096.00, 8192.00, 16384.00, 32768.00, 65536.00, 131072.00, 262144.00, 524288.00, 1048576.00

If there are some unusual requirements for specific frequencies, we can replace the fundamental crystals on the board to change the possible outputs. Also note that frequencies can be “nudged” by as much as 0.001% by adding or removing capacitors. In situations with very tight tolerances (<10ppm) this is basically required.

4.3.3 Duty Cycle
The G0, G1, and G2 clocks only have a 50% duty-cycle when set to frequencies below 350Mhz. Above this frequency the duty cycle is not guaranteed. Experimentally, it is shown to be better than 60/40 at high frequencies.

4.3.4 Jitter
The jitter performance of the G0, G1 and G2 synthesizers is very good, but will be a severe limitation at interface speeds above 400Mhz. Use the Virtex 5 PLLs.

4.4 Ext Clocks
There are two clock networks on the DN9002K10PCI that are designed to provide clocks from an external frequency reference. EXT0 and EXT1. Each of these clocks is delivered synchronously to all 6 FPGAs and is suitable for synchronous communication among the FPGAs.

4.4.1 EXT0
This clock can be sources from either the external clock input SMAs connectors or daughtercard A.

By default, EXT0 is set to be sourced from the daughtercard A. The source setting can be made from the USB Controller by selecting settings->DN9002K10PCI clock source.

The syntax for setting this clock from the main.txt file is not yet specified. Contact support@dinigroup.com

If you are writing your own USB or PCI software, the method of changing the source is by writing to a configuration register. To change the current setting write to configuration register 0xDF27.

0xDF28[4:0] = S23, S1, S0, PLLSEL, CLKSEL
To understand the correct settings, you must read the ICS8745B datasheet on the user CD.
When the USB controller or main.txt file set the clock setting to daughtercard or SMA mode, they set the clock buffer on the DN9002K10PCI to bypass mode, which means that the skew between the SMA or daughtercard source, and the receiver FPGA is unknown. If you must use this clock for synchronous communication across the daughtercard, then the buffer must be set into zero-delay mode, by setting the S23, S1, S0 and PLLSEL signals to the correct value. The GUI does not currently support this. Contact support if you require this behavior.

4.4.2 EXT1
This clock can be sourced only from daughtercard B. By default, EXT1 is set to be sourced from the daughtercard B.

4.4.3 Daughtercard zero-delay mode
EXT0 and EXT1 can be set to zero-delay mode, where each FPGA is able to receive the clock synchronous to the daughtercard. This feature requires configuring the clock distribution network with the frequency of the clock. The interface by which the user can do this is not defined. Contact support@dinigroup.com if you require this feature.

Before you attempt to implement this daughtercard clocking method, consider using the DCA and DCB clock pins on each daughtercard to directly clock the daughtercard’s associated FPGA, rather than to drive the global network.

4.4.4 SMA input
The EXT0 clock can be sourced from a pair of SMA inputs, J12, J13. These SMAs connectors are designed to connect to a differential clock source.
The inputs are AC-coupled. This limits the minimum possible frequency of the clock input to around 4 kHz. If you require an external clock with a frequency lower than this, you should modify the board by removing the 4.7uF resistors shown above and replacing them with 0-ohm resistors. The maximum recommended swing on the differential inputs is 3.3V.

To connect a single-ended clock source, you can connect to one of the SMA connectors, and leave the other unconnected.

4.5 PCI Clock
The PCI Clock (“CLKP” in the schematic) is included for the purpose of synchronizing the interface between the QL5064 PCI bridge chip and the FPGA A. The use of this clock with PCI is not described, because the Dini Group provides a module, QL5064_interface_module, that implements the QL5064 connection.

The clock is a single-ended LVCMOS (3.3V) signals distributed to FPGA A, FPGA B, the Spartan Configuration FPGA, and the QL5064. The frequency of the clock is fixed at 75Mhz. This frequency is chosen because it maximizes the performance of the QL5064 chip.

To receive the chip on FPGA A or B, use a LVCMOS33 input. Although the clock is designed to be used with the QL5064_interface_module module, it can be used by the user design as well. Details about how to connect this clock to the QL5064 module are in the QL5064 module documentation on the user CD. Before providing this clock signal to the module, you must pass the signal through a DCM, and pass the CLK0 output of the DCM through a BUFG. The output of this BUFG is connected to the module.

4.6 Non-Global Clocks
The following sections describe clocks that are not considered “global” because they do not distribute to both FPGAs on the board. These clocks may be used for specific interfaces and details on the clocking required for those interfaces are found in a different section in the hardware chapter.

4.6.1 Clock TP
Each FPGA is connected to a two-pinned test point. This test point can be used to input a differential clock from off-board. Each of these test points has a 0-Ohm jumper installed shorting the negative and positive signals. To input or output differentially, you must remove this resistor.
The schematic clipping above shows FPGA B’s test point, but all FPGAs use the same pinout. A list of all test points on the board can be found in the test points section.

This signal can also be used as an external feedback path for a DCM. When connecting the output of a DCM to K14, the DCM FB input can be connected to K15. Using this configuration, output flip-flops connected to CLK0 of the DCM will have an effective clock-to-out time of less than zero.

The test point is connected to FPGA A and B on a 3.3V bank. This limits the type of signaling that these test points can input or output.

### 4.6.2 Ethernet Clock
The VSC8601 Ethernet PHY device outputs a 125Mhz clock. The signals in the schematic are CLK125_ETH. This signal is LVCMOS25, single-ended signals. The frequency is fixed. Details about appropriate clock methodology for the Ethernet interface is in the Ethernet section.

### 4.6.3 DDR2 Clocks
The CK signals in the DDR2 interface are described in the DDR2 interface section.

**OUTPUTS**

- CLK_DIMMB_CK2p  AC33
- CLK_DIMMB_CK2n  AD32
INPUTS
CLK_DIMMB_CK2p  AM28
CLK_DIMMB_CK2n  AN28

Note that on the netlist, these signals connect to the FPGA twice: once on the DDR2 interface bank (1.8V), and once on the global clock input bank (2.5V). The 2.5V, clock bank connections should be used as inputs, and the 1.8V bank signals should be configured as outputs. For input signals, use the LVDSEXT standard with the DIFF_TERM attribute set to TRUE.

4.6.4 SMA Clock A
FPGA A has a pair of SMA connector connected directly to global clock inputs (AM28, AN28). The bank connected to these signals is a +2.5V bank. Allowed input standards are LVCMOS25, SSTL25, LVDS, DIFF_SSTL18.

These connections are DC-coupled, meaning the user must ensure that the levels received on this input are within the limits of the Virtex-5 device to prevent damage to the part.

This pair of SMA connectors can also be used as outputs, or for non-clock signals.

5 Test points
This section lists all of the test points on the DN9002K10PCI. A more detailed description may be found in the section about the system that the test point is part of, but all test points are listed here for reference.
5.1 Power Thru-hole
Each power rail requiring more than 100mA on the DN9002K10PCI has a dedicated test point associated with it. This test point is a through-hole, two-pin location, where pin one is the power rail, and pin two is a ground connection. These test point locations are suitable for supplying at least 2A, regardless of the power requirements or capabilities of the power net.

Pin one is a square. Pin two is circular.

TP14 0.9V_B
TP16 1.0V_A
TP18 1.0V_B
TP23 -12V
TP10 1.8V
TP9 2.5V
TP22 1.2V
TP15 3.3V
TP7 5.0V

Power for the –12V, +5.0V and +3.3V nets are generated off-board.

These test-points are suitable for wiring to if power is needed off-board for some reason. Or maybe if you need to bring power in from an external source.
5.2 Power TP
The following test-points are located along the left edge of the board, next to an LED associated with that power net. These test points are square pads. They are not suitable for supplying power to the board, or off the board.

Power Fail LEDs

The test point reference designator is not visible on the silkscreen of the DN9002K10PCI. Instead, there is a label indicating which power net the test point is connected to. These test points are connected by thin traces that are not capable of conducting more than 100mA of current. You should only use these test points for probing. For noise measurements, it is better to use the test points next to each power supply.

5.3 DIMM Power
As described in the DDR2 Interface section, provisions have been made for the use of +2.5V modules in the memory sockets of the DN9002K10PCI. To allow this, a jumper point is provided for each DDR2 memory power net.
The DN9002K10PCI comes with a jumper installed in each of the “1.8V” test points, shorting the DIMM power supplies to the +1.8V power supply.

<table>
<thead>
<tr>
<th>1.8V</th>
<th>2.5V</th>
<th>DIMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP12</td>
<td>TP13</td>
<td>B</td>
</tr>
<tr>
<td>JP1</td>
<td>1.8V_ADJ</td>
<td></td>
</tr>
</tbody>
</table>

If you require power on any DIMM other than +1.8V, you must remove the installed jumper and instead install a different jumper to connect the DIMM power to +2.5V. If you require +3.3V on this power net, no jumper point is provided, and you will have to run a wire.

### 5.4 “GC” Test points

Each FPGA is connected to a two-pin test point for debugging purposes. This test point is the same as the ones used for the “Power Thru-hole” test points. Each test point is connected to a “GC” pin on the FPGA, meaning it can be used as a differential clock input to the FPGA. By connecting a reference voltage to the “N” pin (circular), this test point can be used to input a single-ended signal.
TP21  A  
TP20  B  
Note that the signals connected to either side of these test points are shorted together by a 5-ohm resistor. This connection allows the use of external clock feedback. If you need to use these test points as two separate IOs, this resistor would have to be removed.

The reference design uses this connection for external clock feedback. The register is called "TPP".

5.5 Clock Test points
Each of the “Global clock” networks has a test point. These points are not length-matched with the global clock network, so there may be some phase offset between this point and the FPGA input.
All of test points output LVDS signaling. LVDS test points have the “p” signal connected to pin 1 (square) and “n” connected to pin 2 (circular).

A 100-ohm resistor connects the P and N side of these clock signals. This is excellent for probing with a high-impedance probe, but not so good for connecting wires. You can remove this resistor if needed.

5.6 DIMM Signals
Some key signals on each DDR2 interface are connected to test points for debugging. The test point pad used is the same as on the “Power TP” test points.

The test points are not labeled with their reference designators. Instead, they are labeled with the signal name.

6 USB interface
The DN9002K10PCI allows the user FPGA to communicate to a host PC over USB. The configuration circuitry allows this by bridging USB to the Main Bus interface. For most users, implementing USB communication will be as simple as making a Main Bus controller. In the reference design, there is an example Main Bus controller. See the Main Bus section of this chapter for more information on the Main Bus.

USB on the DN9002K10PCI also allows control of the configuration circuitry from a host PC. This includes configuring FPGAs, setting clock frequencies and others.
This section will describe the software interface required to communicate to the DN9002K10PCI. In addition to reading this section, you may choose to modify the provided software (USB Controller and AETest_usb). The source code for these programs is on the user CD. These programs collectively implement all of the available controls on the DN9002K10PCI.

6.1 Connecting to the DN9002K10PCI
Depending on the operating system, there are different methods of obtaining a software handle to the DN9002K10PCI in order to access it from software.

6.1.1 Windows XP
What driver is this? It’s the EzUSB driver.

```c
HANDLE handle = CreateFile("\\\Ezusb-0", GENERIC_WRITE,
  FILE_SHARE_WRITE, NULL, OPEN_EXISTING,
  0, NULL);
```

The “EzUsb-0” device name is registered with Windows when installing the EzUSB device driver. The .ini file provided with the driver causes the driver to be assigned to any USB device with VendorID=0x1234 and ProductID=0x1234.

The HANDLE object returned by CreateFile is suitable for use with DeviceIoControl().

6.1.2 Windows Vista
Testing was not complete at print time. support@dinigroup.com

6.1.3 Linux
To use USB in Linux, use the provided usbdrvlinux.c file provided on the user CD in AETest_usb/driver

```c
Connecting to the device occurs using the driver’s usb_open function.

```c
int handle = usb_open(0x1234, 0x1234, 0);
```

6.1.4 Communication
The USB interfaces that the DN9002K10PCI presents are separated into two types: The Vendor requests, and the Bulk Transfers. All other types of USB transactions are not supported. The vendor requests are low-bandwidth control signals used for controlling the board settings. The Bulk Transfers are used for configuring and reading back FPGAs and reading and writing to the main Bus interface.

6.2 Vendor Requests
Most of the “control” functions available over USB are accomplished using a “vendor request”. Programming a USB vendor request is out of the scope of this document, but you can copy the code provided in the USB Controller program.
The following table describes the USB interface presented to the host by the MCU microcontroller.

<table>
<thead>
<tr>
<th>Vendor Request Name</th>
<th>ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR_GET_FLASH_RE</td>
<td>0xA6</td>
<td>Returns a revision code of the “MCU” firmware</td>
</tr>
<tr>
<td>VR_GET_FPGA_INFO</td>
<td>0xA7</td>
<td></td>
</tr>
<tr>
<td>VR_REBOOT</td>
<td>0xAD</td>
<td></td>
</tr>
<tr>
<td>VR_CONFIG</td>
<td>0xAF</td>
<td>Causes MCU to go through configuration sequence (Media Card)</td>
</tr>
<tr>
<td>VR_FLASH_VERSION</td>
<td>0xB2</td>
<td>Reads version of flash code</td>
</tr>
<tr>
<td>VR_DISPLAY_FPGA_INFO</td>
<td>0xB3</td>
<td></td>
</tr>
<tr>
<td>VR_CHECK_FPGA_INFO</td>
<td>0xB4</td>
<td></td>
</tr>
<tr>
<td>VR_CHECK_FPGA_CONFIG</td>
<td>0xB5</td>
<td>Returns a string representing if the selected FPGA is configured</td>
</tr>
<tr>
<td>FLASH_VERSION_ADDR</td>
<td>0x08</td>
<td>Value to go into upper address register (MCU_XADDR)</td>
</tr>
<tr>
<td>VR_SET_EP6TC</td>
<td>0xBB</td>
<td>Sets the size of the bulk transfer (Read) buffer. You must set this to a value equal to the SIZE field of the USB Bulk transfer</td>
</tr>
<tr>
<td>VR_SETUP_CONFIG</td>
<td>0xB7</td>
<td>This vendor request must be called to select an FPGA for configuration prior to a bulk transfer containing the configuration stream for that FPGA.</td>
</tr>
<tr>
<td>VR_END_CONFIG</td>
<td>0xBD</td>
<td>This vendor request de-selects an FPGA after configuration and returns the configuration status of that FPGA (DONE signal)</td>
</tr>
<tr>
<td>VR_MEM_MAPPED</td>
<td>0xBE</td>
<td>This vendor request reads or writes to the address space of the MCU. This vendor request can be used with the configuration register map above to accomplish any configuration task.</td>
</tr>
<tr>
<td>(Config Read)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Config Write)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VR_CLEAR_FPGA</td>
<td>0xB9</td>
<td>Clears the selected FPGA of configuration data.</td>
</tr>
<tr>
<td>VR_BOARD_VERSION</td>
<td></td>
<td>Returns a byte representing the type of board</td>
</tr>
</tbody>
</table>

Each vendor request has a direction, request type, request, and value, size and buffer pointer fields. The request type is always TYPE_VENDOR. The request field is the ID listed in the table above. The value and data in the buffer pointer fields are vendor-request specific. The size field is the number of bytes in the buffer. The details of how to implement a vendor request are outside the scope of this manual.

6.2.1 VR_CLEAR_FPGA
This vendor request clears an FPGA.
Direction is OUT. Size is 0. Value represents which FPGA should be cleared. 0 is FPGA A. 1 is FPGA B… and so on.

**6.2.2 VR_SETUP_CONFIG**

This vendor request must be called before sending configuration data to an FPGA. It tells the DN9002K10PCI which FPGA should receive the next configuration stream sent over USB. It also clears that FPGA of its current configuration.

Direction is OUT. Size is 1. In the buffer is a number representing which FPGA should be selected. 0 is FPGA A, 1 is FPGA B, 2 is FPGA C… and so on.

**6.2.3 VR_END_CONFIG**

This vendor request de-selects and FPGA (so that configuration data sent will go to no FPGA) and checks the configuration status of an FPGA.

**6.2.4 VR_SET_EP6TC (Read buffer size)**

The SetReadBufferSize vendor request must be used before any “bulk read” bulk transfer. This sets the size (in bytes) of the data that will be requested by the bulk transfer. If this vendor request is not sent before the bulk read, the behavior is undefined.

The direction is OUT. The size is 0. The value is the number of bytes required for the next bulk transfer.

**6.2.5 VR_MEM_MAPPED (Configuration Registers)**

Some of the controls on the DN9002K10PCI do not have their own Vendor Request. These functions include setting the clock frequencies. In order to accomplish these tasks, you must use the “Configuration Registers”. The full list of registers is in the “Configuration Section” section. To write to a configuration register, use the VR_MEMORY_MAPPED vendor request.

The direction is OUT. The value field is the address you wish to write to (example 0xDF39, the disable Main Bus register). The size field should be 1. The buffer should contain a single byte containing the byte to be written to the Configuration Register. All configuration registers are one byte.

**6.2.6 Other Vendor Requests**

Many of the Vendor requests used by the USB Controller program are not documented. Dini Group does not support these requests for users. If you need a function that you feel is not described here, contact support@dinigroup.com

**6.3 Main Bus accesses**

The USB Controller control the DN9002K10PCI reference design using USB vendor requests and bulk transfers that access the configuration FPGAs registers. These registers cause “Main Bus” transactions with the user FPGAs. The host computer initiates all Main Bus transactions. To see a specification of the Main Bus interface, see Reference Design.
To request a Main Bus interface write transaction, the USB Controller program sends a USB bulk write to EP2 (endpoint 2). The first byte contains a code, either 0x00 or 0x01, determining whether the next 4 bytes contain an address or a datum. If this byte is a 0x00, the next 4 bytes in the bulk transfer are stored into an address register. All data transferred to and from the main bus is LSB first. The address 0x12345678 should be sent as a bulk transfer of 5 bytes: 0x00, 0x78, 0x56, 0x34, 0x12. To send a datum, send the code 0x01, followed by 4 bytes, LSB first. When the DN9002K10PCI receives a data word, it sends it onto the main bus interface to the address in the address register. It then increments the address register. Therefore, to send two words over main bus, 0x00000001 to address 0x00000001 and 0x00000002 to address 0x00000002, the USB Controller would send the following 15 bytes to USB EP2:

0x00 0x01 0x00 0x00 0x00
0x01 0x01 0x00 0x00 0x00
0x01 0x02 0x00 0x00 0x00

Note that the number of bytes sent to EP2 must be divisible by 5.

To request a main bus read operation, the USB Controller sends a USB bulk write to EP2 to set the address register, as described in the above paragraph. Then, the USB Controller sends a bulk read to EP6 (endpoint 6), with the USB bulk request SIZE field set to the number of bytes requested. The number requested must be divisible by 4. After the bulk read is complete, the address register is incremented by SIZE/4. Read and write transactions use the same

Before starting a USB read using a bulk transfer, you must tell the DN9002K10PCI how many bytes are going to be read by using the VR_SET_EP6TC (0xBB) vendor request described in the Vendor Requests section.

6.3.1 Important Note About Endpoints
There is only one endpoint that the user should use: endpoint 2. Note that an endpoint is bi-directional. Using the driver that Dini group provides, the endpoint and direction fields are stuffed within the same byte. To write to endpoint 2, this byte should be 0x02. To read, it should be 0x08. Some people refer to these as uni-directional endpoints 2 and 8.

6.3.2 Performance
Main Bus over USB runs at a maximum speed of 80Mbs for reads, and 32Mbs for writes. These numbers assume that the FPGA operates the Main Bus interface with zero wait cycles. If the FPGA design has more wait cycles, this speeds decreases. The approximate speed of Main Bus over USB is given below as a function of Main Bus wait states.

<table>
<thead>
<tr>
<th>Cycles</th>
<th>Read Speed</th>
<th>Write Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80Mbs</td>
<td>32Mbs</td>
</tr>
<tr>
<td>1</td>
<td>76Mbs</td>
<td>31Mbs</td>
</tr>
<tr>
<td>5</td>
<td>64Mbs</td>
<td>29Mbs</td>
</tr>
<tr>
<td>30</td>
<td>32Mbs</td>
<td>16Mbs</td>
</tr>
<tr>
<td>100</td>
<td>13Mbs</td>
<td>11Mbs</td>
</tr>
<tr>
<td>250</td>
<td>6Mbs</td>
<td>5Mbs</td>
</tr>
</tbody>
</table>
6.4 FPGA Configuration

The following procedure is used by software on the host computer to configure an FPGA over USB. This procedure is followed by the USBController program and AETest_usb program on the user CD.

1) USB Software gets a handle to a USB device with VID 0x1234 PID 0x1234.

2) USB host software sends vendor request VR_SETUP_CONFIG 0xB7 (see Vendor Requests) with 1 byte in the data buffer representing which FPGA to configure. (A is 0x01, B is 0x02, C is 0x03...)

3) The configuration circuit on receiving this vendor request asserts the PROG signal of the selected FPGA. This resets the FPGA and clears any configuration data it may already have. This Vendor request also selects the FPGA, so that SelectMap bus activity only affects the selected FPGA. Bulk transfers initiated after this command to endpoint 2 are interpreted as SelectMap transfers, rather than Main Bus transfers. (See Main Bus access above). This will be so until vendor request VR_SETUP_END (0xBD) is called.

4) USB host software sends a bulk write USB request to EP2. Each byte of data in the bulk write is sent to the selected FPGA over the SelectMap bus, and the FPGA signal CCLK is pulsed once for each byte of data sent. Note that the LSBit in the USB transaction is sent to the LSBit in the SelectMap interface, so bit swapping as described in the Virtex 5 Configuration Guide is not required. A standard .bit file from Xilinx bitgen can be transferred in binary over this USB interface to correctly configure an FPGA on the DN9002K10PCI. Make sure CCLK is selected as the startup clock in the bitgen settings. This is the default setting.

5) After an FPGA configures, the DONE signal will go high, lighting the blue LED next to the FPGA (labeled “DONE”).

6) The USB Controller sends a vendor request out VR_SETUP_END (0xBD). This request deselects the FPGA, so that further bulk requests are interpreted as Main Bus transactions.

6.4.1 Readback

This section should be updated when Readback is enabled. If this sentence is here, it means this section has not been verified yet. When the DINI.H API is made available, this section should be removed completely.

Readback is performed in the same way that configuration, except that the direction of the bulk transfer is BULK_READ instead of BULK_WRITE. The commands required by the SelectMap interface to start a Readback must be sent using the configuration interface. For this reason, it is the programmer's responsibility to understand and implement the SelectMap protocol.
6.5 USB Hardware

The actual hardware associated with performing USB communication with the DN9002K10PCI is briefly described here. Since the user is not required to understand how to operate the hardware from the FPGA, much detail is omitted.

6.5.1 Cypress CY7C68013A

A Cypress Micro controller (MCU) with a built-in USB controller provides the USB interface of the DN9002K10PCI. For a low-level understanding of the way the DN9002K10PCI communicates over USB, you should see the Cypress CY7C68013A datasheet. The driver that Dini Group provides is the free Cypress EzUSB driver, with customizations to the corresponding .ini file to identify the board as a “Dini Group Emulator” product.

As with all USB devices, communication with the DN9002K10PCI is initiated by the host (PC) and can be either a USB “vendor request” or “Bulk transfer”. All other types of USB transactions are not supported or documented with the DN9002K10PCI. In general, Bulk transfers are used for high-bandwidth data and vendor requests are used for all other control functions.

**Bulk Transfer Functions:**
- Configure FPGA (SelectMap)
- Readback FPGA (SelectMap)
- MainBus read
- MainBus write

Vendor requests can contain short (512Byte) messages in either direction, and cause the MCU to execute code. In response to most vendor requests, the MCU will modify or read values in the Configuration memory space (see next section).

Since vendor requests can contain only a limited amount of data, USB Bulk transfers are used to send configuration data to the DN9002K10PCI. The MCU is too slow to process USB 2.0 data at full speed, and so the bulk transfer data is sent to external pins on the Cypress MCU (see Cypress datasheet) and to the configuration FPGA (next section). Currently, this data is only used to configure FPGAs, and so the data is sent to the SelectMap pins of the Virtex 5 FPGAs.

To begin communication with the DN9002K10PCI, the USB Controller program creates a USB connection object in the host operating system, by opening Vendor ID 0x1234 product ID 0x1234. (For the purposes of updating the firmware, the DN9002K10PCI can come up in “EPROM” mode, where it loads a program capable of connecting over USB to a host, downloading firmware and writing it to the MCU flash memory, U201. The check the MCU makes on reset to determine which mode it should start in is the firmware update switch, S1 #4. This EPROM code is stored in the EPROM DIP installed in U203. When the MCU is in this mode, it registers itself to the operating system as Vendor ID 0x1234, product ID 0x1233. For firmware update instructions, see USB Software: Firmware Update. For information about the MCU boot up sequence, see Hardware: Configuration Circuit: MCU.)
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The source code for the MCU firmware (“Flash”) is provided in D:\Source Code\MCU\FLASH as a Keil Studios MicroVision 2.11 project file.

6.5.2 Activity LED
A yellow LED located next to the USB connector flickers when there is USB activity.

6.5.3 Configuration FPGA
The MCU unit controls all of the configuration circuits on the DN9002K10PCI, but it does not have sufficient IO to access all of the configuration signals. For IO expansion, the MCU’s external memory bus is connected to a Virtex 5 LX40 FPGA. This FPGA provides a memory-mapped interface to all of its IO. This bus is called the ‘Configuration Bus’.

The configuration FPGA is connected to all of the configuration signals of the Virtex 5 FPGAs, the temperature sensors, status LEDs, SmartMedia card, CompactFlash card, reset buttons, Main Bus switches, RS232 ports, clock synthesizer control signals, global clock multiplexer control signals, FPGA clock inputs, the Main Bus, and an 300-pin expansion header.

The source code for the Configuration FPGA is provided in D:\Source Code\ConfigFPGA
This project can be compiled using Xilinx ISE version 7.1i SP4 or later. Your board may have been build using an LX80 FF1148 or an LX40 FF1148 for the configuration FPGA.

6.5.4 Power
The DN9002K10PCI does not draw any power from the USB connector. Hot-plugging the DN9002K10PCI is acceptable.

6.6 Troubleshooting
If you cannot get USB to communicate with your design over Main Bus, please try using the USB Controller software with your design, and using the Dini Group reference design with your software. This will help determine whether the software or the hardware is causing the error.

6.6.1 USB Controller Freezes
The Vendor requests on the DN9002K10PCI are blocking. Only one can be completed at a time. This includes vendor requests that take a very long time like “Configure from CompactFlash” (10 seconds). During this time USB Controller, a single-threaded application, freezes when any Vendor Request is issued. (All the time).

The only way to work-around this issue is to create a separate board-interaction thread.

6.6.2 Main Bus always returns 0x______ (Error Codes)
0xDEADDEAD
Main Bus timeout. The VALID signal on Main Bus was never asserted. See the Main Bus section for details. Your FPGA may not be configured.
0x12345678
This error code may mean the “Enable USB->FPGA Communication” button in USB Controller has not be pressed (the Main Bus disable register is set)

0xDEAD5566
This error code is returned by the Dini Group reference design when there is a Main Bus read to a register that is not defined. (Default Main Bus output). This code is specific to the reference design.

0xDEAD1234
This sentinel value should not be returned.

0xABCDABCD
This error code is returned when a MainBus register corresponding to a memory is read, but the memory is not implemented in the Reference Design

7 PCI interface
The DN9002K10PCI can be installed in a PCI slot, either 32 or 64 bits, 33 or 66Mhz. It can also be used in a PCI-X slot. (Although the entire bus will only run at 66Mhz in this configuration).

A QuickLogic QL5064 bridge provides PCI on the DN9002K10PCI. This device has a PCI controller on the front end, and an FPGA on the back end. The Dini Group has pre-programmed this device to provide a simple FIFO interface.
Access to PCI is split between the configuration circuit and FPGA A. Access to the configuration functions of the DN9002K10PCI (FPGA configuration, clocks, etc.) are controlled by the configuration circuit and do not use FPGA A at all.

The user design in FPGA A can access BAR 2,3,4,5 and two DMA channels. Bar 0 and 1 are reserved by the QL5064 control functions and by the configuration circuitry of the DN9002K10PCI. Since there is a PCI device controller in the QL5064, the PCI protocol controller does not need to take any of the user space in the FPGA, however, the Dini Group provides an interface module that should be used in FPGA A. This module takes care of IO and clocking concerns, and arbitration of some signals on the QL5064 that are shared with the configuration circuitry.

7.1 FPGA Interface
The FPGA is required to use the supplied “QL5064_Interface_module” provided on the user CD. This module provides an east FIFO interface for target accesses and DMA. This interface is described briefly here, but you should see the document on the user CD:

D:\FPGA_Reference_Designs\DN9002K10PCI\PCI_interface\QL5064_Interface_Module.pdf
A basic block diagram of the entire PCI system, including the QL5064_interface_module module is shown above. The module supports target access and two independent DMA channels. The QL5064 supports DMA chaining (i.e. scatter gather) for DMA channel 0 only. The inputs "clock" and "pci_clock" should be generated by a DCM->BUFG configuration (i.e., the required BUFG is not instantiated inside the module). "Pci_clock" should be connected to the PCLK_A signal (FPGA input). "Clock" may be generated from any FPGA clock input (CLK_G0A, G1, or even PCLK_A). Connect all "QL_" signals directly from the...
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top-level input to this module (no buffers or flip-flops should be inserted). The FPGA
designer need only be concerned about the signals in the “FPGA INTERFACE” side of the
module.

The user (“FPGA”) interface presents 6 separate interface ports: Target Write, Target Read,
DMA R0, DMA R1, DMA T0, and DMA T1. The Target Write and Target Read interfaces
share BAR and address lines, as target reads and writes cannot happen simultaneously. Each
interface has its own "enable", "accept", and "data" ports. Read interfaces also have a
"data_valid" port. The "enable" signals are held active until the associated "accept" signal goes
active. The "accept" signal for an interface may be tied high if it is guaranteed that transfers for
that interface can be accepted every clock cycle (i.e. if the interface is connected to a block
RAM). "Data_valid" can be pulsed with the "accept" signal, or any time after- this allows reads
to be pipelined.

For the purposes of simulation, a model of the QL5064 is provided. The QL5064 “FPGA”
portion should not be considered part of the user design space, and development on this code
should not be done.

7.1.1 FPGA-initiated DMA
You need to set up the QL5064 DMA engine with the same address and byte-count as your
DMA core, so that the data is passed through both FIFOs seamlessly. For example, if you want
to write a block of data to the PCI bus, you would do the following:

Write PCI address to QL5064 register 0x00 (T0 address)
Write source address to your DMA core
Write byte count to QL5064 register 0x08 (T0 transfer count)
Write byte count to your DMA core
Write a 1 to QL5064 register 0x90 bit 16 (T0 start)
Start your DMA transfer

If you do these steps, your DMA core should start fetching data and send it to the T0 FIFO at
QL5064 register 0xc0. The QL5064 will take whatever data you give it, and use its DMA engine
to write it to the address you chose. You may want to set up a hardware wrapper with a state
machine that will accept DMA information from your core and automatically route it to the
correct QL5064 registers, so that you don't need to change any software. This is what I meant
by glue logic, in my previous email.

The alternative to this method is to use SPCI transfers, which is a way to set up a single PCI
write or read in the QL5064. This is much slower, but it requires fewer QL5064 control
registers to be accessed, and gives you more direct control over the transfers sent to the PCI
bus. The register descriptions needed for either option are in the manual that I attached with
my previous email.
7.2 Host Interface, Software

Example software capable of configuring FPGAs, communicating over MainBus and DMA transfers to FPGA A is provided (AETest). You may wish to copy this code and use it as a starting point.

To communicate with the DN9002K10PCI, you will need to find the device on the PCI Bus with VendorID=17DF and DeviceID=1864. The device will register itself with the operating system as "Dini Group PCI Board W/QL5064 Bridge" (OS dependant). Note that many Dini Group products use this vendor and device ID, so differentiating between boards requires you to read at a minimum, the board type register and the board serial number register.

The size of each bar is
8MB for BAR0 (23 read-only bits)
16MB for BAR1-5 (24 read-only bits)

All 6 BARs are 32-bit pre-fetchable memory space. This setup allows most systems for meet the memory requirements.

7.2.1 Driver

The source code for the DN9002K10PCI's PCI driver is provided.

Windows XP

Binaries for 32-bit windows, 64-bit windows (Intel) and 64-bit windows (AMD) are provided as a binary. Use the windows hardware manager to install these drivers. Source is provided, but shouldn't be required.

Legacy Windows

Versions of Windows older than XP exist, but are not maintained. Contact support@dinigroup.com for details.

DOS

Under DOS, only direct device access is supported. The DOS version of AETest program does not use a driver.

7.2.2 Board Settings

Board settings (clocks, FPGA temperatures, etc.) can be changed over PCI by accessing the “Configuration Register” interface. A description of the registers in this interface is in the Configuration Section of this chapter.

Writes

To write to a configuration register, write to BAR0, offset 0x258. Send a 32-bit word of data. This data is decoded as follows
Bits 31-16: “Configuration Register” address in (only addresses 0xDF00-0xFFFF are valid. See the “Configuration Register” map in the “Configuration Section” section)

Bits 15-8: Ignored

Bits 7-0: The Data value to write to the register

**Reads**

To read from a configuration register, read one byte from PCI at the following 32-bit address:

Bits 31-24: The DN9002K10PCI’s BAR0

Bits 23-16: the lower 8 bits of the address of the configuration register you would like to read. (The upper 8 bits must be 0xDF, or the read will not be valid).

Bits 15-0: 0x0260

**Example**

Example: Set clock G0 to 250Mhz

Step 1) Determine the M and N values required for the G0 PLL. See the clocking section to details on the G0 clock synthesis. (The correct values are M=20 and N=2)

Step 2) Look on the “Configuration Registers” memory map in the *Configuration Section* and find the entries for G0 M (multiply) and G0 N (divide) values.

Step 3) Write to the G0 M register the value 0x14 (20). Write to BAR0, offset 0x258: 0xDF300014

Step 4) Write to the G0 N register the value 0x01 (2). Write to BAR0, offset 0x258: 0xDF290001

Step 5) Write to the UPDATE_FLAG register the value 0x01 (CLK G0). Write to BAR0, offset 0x258: 0xDF400001

**7.2.3 Main Bus**

The Main Bus interface is how you can communicate to all FPGAs on the DN9002K10PCI over PCI (not just FPGA A). The bandwidth available over the Main Bus is much lower than that of PCI, so performance is not as great using this method. For details about the Main Bus, see the Main Bus section in this chapter.

To write to Main Bus over PCI, write to BAR0 at the address QLPCI_REG_MBADDR with the 32-bit value representing the main bus address you would like to write to. Then, write a second PCI write to address QLPCI_REG_MBWRDATA with 32-bit data representing the
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data that you would like to write to main bus. After the Spartan 3 has received a write to both
the MBADDR and MBWRDATA registers, it will write to the main bus interface.

To read from the Main Bus over PCI, first write to BAR0 address QLPCI_REG_MBADDR
with the 32-bit value representing the main bus address you would like to read from. Then, read
from BAR0, QLPCI_REG_MBRDDATA. The returned value will be the value read off the
main bus at the selected address. When an error has occurred (No FPGA responded to the read
request) the read will return the value 0xABCDABCD.

QLPCI_REG_MBADDR  0x240
QLPCI_REG_MBCtrl  0x244
QLPCI_REG_MBWRDATA  0x248
QLPCI_REG_MBRDDATA  0x250

7.2.4 FPGA Configuration
FPGAs can be configured over PCI. Data from PCI is directed to the SelectMap interface of
the Virtex-4 FPGAs, and in this way, a host can cause the FPGAs to configure.

To send configuration data to an FPGA

- “Select” an FPGA. Write one 32-bit word to BAR0, address 0x208. The word
  represents which FPGA should be “selected”. The data 0x11 represents FPGA A, 0x12
  is FPGA B.

- Reset the selected FPGA. A full-chip reset is recommended before configuring an
  FPGA. To reset an FPGA, the configuration circuit asserts the FPGA PROGn signal.
  This process clears a device of any configuration it may have.

- Read the current initialization state of the selected FPGA. If it is ready to configure, it
  asserts the INTn signal. To read this signal read BAR0 address 0x208, bit 6.

- After the INTn signal is detected, the Host should de-assert PROGn (Reset). Write to
  BAR0 address 0x208 the data word representing the selected FPGA. 0x11 is FPGA A,
  0x12 is FPGA B.

- The configuration stream for the FPGA is then sent to BAR0, address 0x210, one byte
  at a time. Sometime during the configuration stream byte loading process, a startup
  sequence is sent to the FPGA and the FPGA becomes operational. This startup
  sequence is contained within the bit file.

- To determine of the selected FPGA is currently configured (i.e. configuration was
  successful), read from BAR0 address 0x208. The bit 5 contains the state of the DONE
  FPGA pin, the bit 6 contains the state of the FPGA INIT signal.
By convention, the host program should leave the Spartan in the FPGA deselected state. To deselect the FPGA, write to BAR0, address 0x208 the data 0x10. (FPGA SELECT NONE)

This interface can also be used for Readback. The configuration section does not implement the SelectMap protocol, so the host application would be required to implement the necessary SelectMap instructions. See the Virtex-5 Configuration Guide for the SelectMap interface description.

To read configuration data from an FPGA, <not implemented at print time contact Dini Group support>

7.2.5 Direct PCI to FPGA, DMA
Detail about the software required by the host of the DN9002K10PCI can be found in

D:\FPGA_Reference_Designs\DN9002K10PCI\PCI_interface\QL5064_Interface_Module.pdf

This document should be used to design software to access the user design in FPGA A. DMA in particular requires accessing the QL5064 registers (in BAR0) to setup each transaction.

Using the device driver provided use the dma_scatter_gather_read() and dma_scatter_gather_write() functions.

Performance has been characterized using the DN9002K10PCI reference design on Windows XP on a MSI MS6728 motherboard using the AETest application. The speeds are:

Read (DN9002K10PCI to software): 700Mbs
Write (software to DN9002K10PCI): 350Mbs

7.2.6 Direct PCI to FPGA A, Target access
If DMA is not required, accessing FPGA A from the host software is easy. Simply read or write to an address in BAR 1,2,3,4 or 5.

7.2.7 Performance
Performance is dependent on a lot of things, including the quality of the motherboard/chipset, and any delays in the FPGA logic. Also, using a 66Mhz or 64-bit PCI slot can improve performance in some situations. The following figures are given for a “Typical” system: 2Ghz processor with a 33MHz, 32bit PCI slot running 32-bit Windows XP. The FPGA in this typical design responds to PCI requests quickly.

When using the driver function IOCTL_DNDEV_BAR_READ_BUFFER to do target read accesses, each read transaction (32-bit) takes an average of 40 PCI clock cycles, with an additional 150 PCI cycles of overhead for each driver call. This means that, depending on whether reads are sequential (so each driver call can read multiple words), performance will range from 0.88MB/s to 3.3MB/s
When using the driver function IOCTL_DNDEV_BAR_WRITE_BUFFER to do target access writes, each transaction (32 bit) takes an average of 4 PCI clock cycles, with an additional 100 PCI clock cycles of overhead for each driver call. This means that, depending on whether writes are sequential (so each driver call can write multiple words), performance will range from 1.3MB/s to 33MB/s.

When using the driver function IOCTL_DNDEV_DNQL_DMA_WRITE to do DMA access writes, as the size of the buffer increases, write performance will approach 33MB/s and read performance will approach 81MB/s.

When accessing MainBus using PCI registers, performance will be equal to the least efficient target access numbers: 0.88MB/s reads and 1.3MB/s writes.

If you require performance greater than the values given above, contact Dini Group and we can suggest ways of improving throughput.

7.2.8 64-bit addressing
Works now. Requires a 64-bit PCI addressing is available on machines that have both a 64-bit processor and 64-bit OS. The driver must be re-compiled from the source code to support your system, using an appropriate build environment.

7.3 Host Interface, Electrical
The DN9002K10PCI is compatible with 32 or 64 bit PCI slots. It can operate at 33 or 66Mhz, at 3.3V or 5.0V. You can also install into a PCI-X slot, and the PCI-X bus will automatically revert to a 66 MHz, 64-bit PCI bus.

Be careful not to install the DN9002K10PCI backwards in a PCI slot. Since the edge connector on the DN9002K10PCI is universal, it will happily fit into the PCI slot backwards… Until it self-immolates.

7.3.1 Power
The DN9002K10PCI current capacity greatly exceeds the maximum allowed power requirements for a PCI card (35W). The DN9002K10PCI is designed so that external power can be applied so the card will function in slots that require cards follow the specification (many servers). See the power section in this chapter for instructions.

The DN9002K10PCI is not designed to support PCI hot plug. Turn off the DN9002K10PCI and host before connecting PCI.

7.3.2 PCI-X
The QL5064 is not capable of PCI-X, therefore, the DN9002K10PCI is not capable of PCI-X. However, the board will correctly work in a PCI-X slot, reverting the entire bus to a 64 bit, 66 MHz PCI bus.
7.3.3 PCI Frequency
No hardware changes are required to operate the board at 66 MHz, 33Mhz. You can operate
the PCI bus at DC speeds also. Dini Group has products that can help you with this. Contact
sales@dinigroup.com

7.4 Host Interface, Mechanical
The DN9002K10PCI meets the requirements for a PCI add-in card for the following
dimensions:

- IO placement for USB and Compact Flash.
- 64-bit connector for 3.3V or 5.0V

It fails to meet the PCI requirements for the following dimensions:

- IO placement for daughtercards, jtag headers, SMA connectors -32-bit connector -Component
  height, top side -Component height, bottom side -Board height -Board length

Therefore, the acceptability of each of these board dimensions is the users responsibility. In
general, large "ATX" compatible computer cases will fit the DN9002K10PCI, given that there is
no PCI card in the right adjacent slot, and not a "tall" card in the left adjacent slot.

Some cases may prevent the use of the DN9000k10PCI because the card slot guides are PCI
length and not ISA length. Also, the DN9000K10PCI will always physically fit into a 32-bit PCI
connector; however there may be components on the motherboard that prevent the board from
plugging it.
Typically there is at least one slot on a generic motherboard that will accommodate the
DN9002k10PCI.

7.5 Hardware Design Notes
The interface between the FPGA and the QL5064 PCI bridge is described briefly in the

D:\FPGA_Reference_Designs\DN9002K10PCI\PCI_interface\QL5064_Interface_Module.pdf

It is recommended that users simply implement the QL5064 interface module instead of trying
to directly interface to the QL5064. The interface details are therefore only provided on request.

FPGA A and the “Spartan” configuration FPGA share the Data bus between the FPGA and
the QL5064. This is how configuration of FPGAs over PCI is possible. In order to prevent the
Spartan and FPGA A from interfering with each other, arbitration is necessary. The provided
QL5064_interface_module module takes care of this arbitration for you. However, a
misbehaving design in FPGA A can prevent the DN9002K10PCI to behave properly over PCI.

The timing of the interface between FPGA A, the QL5064 and the Spartan is fully synchronous
to an external, 75 MHz oscillator. This signal, PCLK is only distributed to these three endpoints.
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The user is free to use the 75 MHz clock inputs for any purpose in addition to clocking the QL5064InterfaceModule module.

Note that the 64-bit, bi-directional, 75 MHz interfaces between FPGA A and the QL5064 has enough bandwidth to fully saturate PCI.

The signals between the QL5064 and the FPGA A are 3.3V, LVCMOS signals.

There is a yellow LED, DS149 indicating activity on the PCI bus. This LED is located near the PCI edge connector.

7.6 Troubleshooting
If under PCI, the board always returns 0xFFFFFFFF this indicates that the Quick Logic 5064 has not been configured by the host system. Usually, this happens a few seconds after the computer starts up. The host system accesses the QL5064 on the DN9002K10PCI and writes to registers in the device to tell it what its assigned address ranges are. If these registers are not set, the QL5064 will not know which bus transactions it should respond to and the bus will return 0xFFFFFFFF on an error.

One situation that can cause the QL5064 is if the user fails to respond to one or more accesses to an unused BAR. If you do not wish to use a BAR, you should respond to requests on unused BARs anyway.

8 Unusable pins

8.1.1 Configuration
The following pins (All FPGAs) are the Select Map data pins, used to configure the FPGAs. These pins are connected to both Virtex-5 FPGAs. Using these signals for FPGA interconnect is possible, but may interfere with the configuration circuitry on the DN9002K10PCI.

| AJ13 | AK13 |
| AJ28 | AK29 |
| AL15 | AL14 |
| AJ26 | AJ27 |
| AK28 | AK27 |
| AL16 | AK17 |
| AM29 | AN30 |
| AN16 |   |
9 System Monitor/ADC

The new Virtex 5 feature System Monitor allows the FPGA to use some of its IO as analog-to-digital inputs.

The voltage measurements at these inputs are referenced to the voltage on the pin VREFP. On the DN9002K10PCI, this voltage is generated by a high-precision external voltage reference IC.

The primary ADC input is routed to a differential test point. There is one test point labeled “ADC” for each FPGA.

Some of the auxiliary inputs to the ADC are routed to the Mictor connector on FPGA B. This could be used for something I guess.

10 Reset

There are two reset circuits on the DN9002K10PCI. One is the power-on reset, or “Hard Reset”, that holds the board, including the configuration circuitry in reset until all power supplies on the board are within their tolerances. The second reset circuit is the user reset, or “Soft reset”.

10.1 Power Reset

The power-reset signal holds the configuration circuit (including a micro controller and Spartan 3 FPGA) in reset. It also causes the FPGAs to become un-configured, and causes the RSTn signal on the daughter cards to be asserted. When the board is “in reset”, the “Hard Reset” LED, DS85, is lit red. It is located about an inch above the USB connector.
When the board is in reset, FPGAs cannot be configured, USB does not function (the host computer will not be able to communicate with the device), PCI cannot access the FPGA or configuration functions (the device will still be accessible from PCI, and QL5064 registers can still be read and written). When in reset, the Spartan configuration FPGA remains configured, but all of the logic in the device is cleared.

Pressing the “HARD RESET” button, S1, located near the ATX power connector, can trigger the Power reset. This reset cannot be triggered over PCI or USB. It is also triggered with one or more voltages on the board fall below, or above a certain threshold. These thresholds are given below:

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0V (A):</td>
<td>0.94V</td>
<td>1.1V</td>
</tr>
<tr>
<td>1.0V (B):</td>
<td>0.94V</td>
<td>1.1V</td>
</tr>
<tr>
<td>1.8V:</td>
<td>1.67V</td>
<td>3.8V</td>
</tr>
<tr>
<td>3.3V:</td>
<td>2.7V</td>
<td>3.8V</td>
</tr>
<tr>
<td>5.0V:</td>
<td>4.0V</td>
<td>5.6V</td>
</tr>
<tr>
<td>12V:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2.5V</td>
<td>2.25V</td>
<td>2.7V</td>
</tr>
</tbody>
</table>

When the board comes out of reset, the micro controller goes through an initialization process that will cause all current settings to be lost, including clock settings. Also, the configuration circuit will act as if the board has just powered on and read from the main.txt file to configure FPGAs.

When the board comes out of reset, the micro controller goes through an initialization process that will cause all current settings to be lost, including clock settings. Also, the configuration circuit will act as if the board has just powered on and read from the main.txt file to configure FPGAs.

When reset is triggered, it remains triggered until 55us after all trigger conditions are removed. This behavior prevents USB from behaving in such a way to permanently disable USB on the host machine.

Under some conditions, the DN9002K10PCI can fail to be responsive after rapidly asserting and de-asserting reset, or if the board is powered off and back on very quickly. This behavior is caused due to a flaw in the micro controller used for the DN9002K10PCI configuration circuit. This flaw is believed to be mitigated by the reset circuitry on the DN9002K10PCI. If you experience the behavior please report it to support@dinigroup.com

### 10.2 User Reset

The “USER RESET” circuit is intended for use by the user. When this reset is asserted, the RESET_*# signal (from the schematic), is asserted to each FPGA. After at least 200ns, this signal is de-asserted simultaneously to each FPGA. This signal is connected to a regular user IO on the FPGA, so it is up to the FPGA designer to implement reset correctly within his design.

The User Reset is asserted whenever the “User Reset” button is pressed. This button, S2, is located just above the USB connector. There is no LED indicating the state of user reset. User reset is also asserted when the reset vendor request is sent over USB.
When User reset is asserted, the RSTn signal to each daughtercard is also asserted.

The rise time of the reset signal is fairly slow (10s of nanoseconds), and the delay within the FPGA of the reset signal cause the actual de-assertion time of the logic within the FPGA to be uncertain by as many as 20ns. (the timing of a synchronous reset within a single FPGA is guaranteed) This means that if this signal is used to reset circuitry used for inter-FPGA communication, care needs to be taken that a synchronous reset is not required for the multiple-FPGA system to operate correctly. Alternately, you design can re-generate a synchronous reset and distribute this signal using a MB* signal.

11 JTAG

There are two JTAG headers on the DN9002K10PCI. The first is used only to update the board’s firmware. The second, J1 is connected to the JTAG port of the Virtex-5 FPGAs. This interface can be used for configuring the FPGAs, or using debugging tools like ChipScope or Identify.

11.1 FPGA JTAG

The connector for FPGA JTAG is shown below.

Note that the signal “TDO” on the header and in the schematic refers to the “TDO” port of the FPGA, not the connector.

The order of the FPGA JTAG chain is FPGA A->FPGA B. There are no other components in the chain. If you received your board with fewer than two FPGAs installed, then the chain will be shorter.
The voltage of the JTAG chain is fixed at 2.5V and cannot change. Hot-plug on this header is allowed.

11.1.1 Compatible Configuration Devices
The JTAG header is designed to work with the Xilinx Parallel IV or Platform USB cable. The JTAG chain is tested at manufacture using a Platform USB cable at 12Mhz.

The driver installation process for the Platform USB cable is relatively difficult for a USB device. Follow the instructions carefully.

In order to achieve high-speed configuration using a Parallel IV cable, you need to enable ECP mode on your parallel port. This is probably a BIOS setting on your computer.

11.1.2 Identify
In order to use JTAG debugging tools on the DN9002K10PCI, you do not need to configure via JTAG.

11.1.3 ChipScope
In order to use JTAG debugging tools on the DN9002K10PCI, you do not need to configure via JTAG.

11.2 Firmware Update Header
The firmware update JTAG header J16, should not be used unless you are updating the DN9002K10PCI firmware. This header is used with a Xilinx Platform USB or Parallel IV cable. The instructions for updating the firmware are in the Controller software chapter.

11.3 Troubleshooting
If you are having problems getting JTAG to work, try connecting the Xilinx Platform USB cable to the JTAG header and running the Xilinx program Impact. Impact will generate a failure log that you can email to support@dinigroup.com. If you have an upgraded board, please mention this in your email.

12 RS232 Interface
RS232 access is available to all FPGAs through the header P2 "FPGA RS232". To connect to this header, use the provided .1" header-to-DB9 cable to connect to a PC's serial port.

The RS232 transmit and receive signals are connected to each FPGA's pins:

AM13 (TX from FPGA)
AM14 (RX to FPGA)

The TX and RX signals use the RS232 data protocol, so the FPGA will have to implement a UART in its logic.
All FPGA share the same RX and TX signals, so only one FPGA should use the interface at a
time. RS232 requires a 12V to -12V signaling level, which is not available on Virtex5 FPGAs, so
an external RS232 buffer is used.

One the board, pin 1 is marked with a big, unmistakable, white circle dot. On the provided
cable, pin one is marked with a red stripe on the cable. Hot-plugging this connector is acceptable
and encouraged.

The port settings required on the serial ("COM") port of your computer are dependent on the
UART in the FPGA. Since the flow-control signals on the serial cable are not connected to the
FPGA, you cannot use "hardware handshaking".

The other port settings, parity, stop bits, speed and data bits are user design dependent.

### 12.1.1 Configuration RS232
A second RS232 header (P3) is for the configuration circuitry to give feedback to the user. It is
described in the section "Configuration Section".
13 Temperature sensors.

Each FPGA is connected to a temperature monitor. This monitor can internally measure the temperature of the FPGA silicon die. The maximum recommended operating temperature of the FPGA is 85 degrees. The accuracy of the temperature sensor is about ±0 to ±5 degrees. When the configuration circuitry measures the temperature of any FPGA rise above 80 degrees, it will immediately un-configure the hot FPGA, and prevent it from re-configuring. When the temperature drops below 80, the configuration circuitry will again allow the FPGA to configure. When this occurs a message will appear on the CONFIG RS232 port (P3). An example test output is given below.

**********************************************************************
TEMPERATURE ALERT: FPGA A
CURRENT TEMPERATURE: 81 DEGREES C
THRESHOLD TEMPERATURE: 80 DEGREES C
THE FPGA IS BEING CLEARED IN AN ATTEMPT TO PREVENT HEAT DAMAGE.
SOFTWARE WILL PREVENT RECONFIGURATION UNTIL THE TEMPERATURE DROPS A FULL DEGREE BELOW THE THRESHOLD TEMPERATURE.
**********************************************************************

**********************************************************************
TEMPERATURE ALERT: FPGA A
CURRENT TEMPERATURE: 79 DEGREES C
THRESHOLD TEMPERATURE: 80 DEGREES C
THE FPGA HAS DROPPED BELOW THE ALARM THRESHOLD
AND MAY NOW BE RECONFIGURED.
**********************************************************************

The FPGA can safely operate as hot as 120 degrees, but timing is not guaranteed. You can use the temperature setting in the ISE place and route tool to make timing allowances for operating the FPGA out-of-range. If you want to disable the temperature limit on the DN9002K10PCI, you can do that using a menu option in the configuration RS232 interface.

14 Encryption Battery

The Virtex5 FPGA supports bit stream encryption. When using encryption, the FPGA must decode the bitstream using a secret key that is stored in a persistent memory in the FPGA. When the DN9002K10PCI is powered off, a voltage is supplied to the FPGA by a battery installed in socket X2.

X2 is designed to house a CR1220-type lithium coin-cell battery. Typically, these batteries produce 3.0V. The socket may also work with battery types DB-T13, L04, PA. These however, have not been tested. Insert the battery positive side up.
The same battery is used for both FPGAs. Removing the battery will cause the FPGAs to lose their encryption memories, and will have to be re-programmed before they can work with encrypted bitfiles again.

To create encrypted bitfiles, turn on the “encryption” option in bitgen. The program will produce an additional output file with an .nky extension. Use the program impact with a Platform USB JTAG cable (plugged into the FPGA JTAG connector on the DN9002K10PCI) to load this .nky file into each FPGA.

When using a bitfile with encryption enabled, the DN9002K10PCI will not be able to read the FPGA type out of the bitstream. It will therefore prevent your FPGA design from loading into the FPGA. To disable this behavior, you must disable sanity check. Adding the following line to your main.txt file can do this

Sanity check: n

Also, when using encryption, you must be careful to correctly set the "startup clock" option correctly in bitgen, or the FPGA will fail to configure.

Whatever you do, if you love your FPGAs, do not disable the “CRC Check” option in bitgen. They should have called this option “Do you want your FPGAs to not catch on fire?”

15 LED Interface

This section lists all of the LEDs. More detailed explanations of the LED functions may be in the sections describing the board system that contains the LED.

15.1 Configuration Section LEDs

These LEDs are controlled by the configuration section and give the status of the board.

<table>
<thead>
<tr>
<th>LED Reference Designator</th>
<th>LED Color</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
</table>
DS9 GREEN ON (3.3V) The board is powered on  
DS56 GREEN SPARTAN_DONE Configuration circuit is on (Firmware loaded)

<table>
<thead>
<tr>
<th>LED Reference</th>
<th>LED</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designator</td>
<td>Color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS10</td>
<td>GREEN</td>
<td>A DONE</td>
<td>FPGA A is configured</td>
</tr>
<tr>
<td>DS12</td>
<td>GREEN</td>
<td>B DONE</td>
<td>FPGA B is configured</td>
</tr>
<tr>
<td>DS13</td>
<td>YELLOW</td>
<td>USB ACT</td>
<td>There is USB activity</td>
</tr>
<tr>
<td>DS55</td>
<td>YELLOW</td>
<td>CF ACT</td>
<td>There is CompactFlash activity</td>
</tr>
<tr>
<td>DS54</td>
<td>YELLOW</td>
<td>PCI_ACT</td>
<td>There is PCI activity</td>
</tr>
</tbody>
</table>

### 15.2 User LEDs

These LEDs are connected to an FPGA and are controlled by the user. The meaning of the LED is design-dependent. Below is the general circuit used to connect user LEDs. To turn the LED on, drive the signal low. To turn off, tri-state or drive-high the signal.

The user LEDs are connected to banks where the daughtercards are connected. The “Bank Voltage” may not match the LED’s current source voltage. In this case, use the drive standard corresponding to the bank, and not the LED. For example, when a LVCMOS25 daughtercard is attached and all other signals on the bank are using the LVCMOS25 standard, and then use the LVCMOS25 standard for the LED on that bank. Do not use DCI on LED signals. You can control the brightness of LEDs by either using a low-drive setting (DRIVE=2mA in the .ucf file), or by rapidly toggling the LED signal high and low.

<table>
<thead>
<tr>
<th>LED Reference</th>
<th>LED</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designator</td>
<td>Color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS19-42</td>
<td>YELLOW</td>
<td>LED A</td>
<td>User LEDs. Drive with LVCMOS</td>
</tr>
<tr>
<td>DS43-53</td>
<td>YELLOW</td>
<td>LED B</td>
<td>User LEDs. Drive with LVCMOS</td>
</tr>
</tbody>
</table>

The number of LEDs available for the user on FPGA A is 24. FPGA B has 11 LEDs. User LED’s on FPGA A and B are numbered 0 to 23. The location of the IOs to use for these LEDs can be found in the provided UCF file or the netlist. The name of each LED is labeled in silkscreen next to the LED.

### 15.3 Ethernet LEDs

These LEDs are controlled by the Ethernet PHYs connected to FPGA B. They can also be user-controller by setting registers in the serial interface of the PHYs.
T1 and T2 are the RJ45 jacks on the top edge of the board. There is a yellow and a green LED embedded in this connector, facing the board edge.

<table>
<thead>
<tr>
<th>LED Reference Designator</th>
<th>LED Color</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>GREEN</td>
<td>ETH_LINK1000</td>
<td>Ethernet PHY has established link, 1000Base-T</td>
</tr>
<tr>
<td>T1</td>
<td>YELLOW</td>
<td>ETH_ACT</td>
<td>Ethernet PHY has detected activity</td>
</tr>
<tr>
<td>DS11</td>
<td>GREEN</td>
<td>ETH_LINK100</td>
<td>Ethernet PHY has established link, 100Base-</td>
</tr>
</tbody>
</table>

15.4 Power LEDs
These LEDs indicate if one or more power supplies fail, either outputting a voltage that is too high or too low. The voltage that the LED indicates is marked in silkscreen near the LED.

<table>
<thead>
<tr>
<th>LED Reference Designator</th>
<th>LED Color</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS6, DS5</td>
<td>RED</td>
<td>POWER_FAIL</td>
<td>One of the 1.0V power supplied has failed</td>
</tr>
<tr>
<td>DS1,2,3,4</td>
<td>RED</td>
<td>POWER_FAIL</td>
<td>One of the board power supplied has failed</td>
</tr>
<tr>
<td>DS14</td>
<td>RED</td>
<td>RESET</td>
<td>The board is in &quot;reset&quot;</td>
</tr>
</tbody>
</table>
15.5 Unused LEDs
These LEDs are controlled by the configuration circuitry. At print time, the meaning of these LEDs was undefined.

These LEDs often blink just when you least expect them to.

<table>
<thead>
<tr>
<th>LED Reference Designator</th>
<th>LED Color</th>
<th>Signal Name</th>
<th>The LED indicates the following when ON.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS15-18</td>
<td>RED</td>
<td>MCU</td>
<td>No meaning.</td>
</tr>
<tr>
<td>DS61</td>
<td>YELLOW</td>
<td>HOST_ACT</td>
<td>No meaning.</td>
</tr>
<tr>
<td>DS57-60</td>
<td>GREEN</td>
<td>LED_SPARTAN</td>
<td>No meaning.</td>
</tr>
<tr>
<td>DS8</td>
<td>RED</td>
<td>ERR_TEMP</td>
<td>FPGA over temperature</td>
</tr>
<tr>
<td>DS7</td>
<td>RED</td>
<td>ERR_CONF</td>
<td>No meaning.</td>
</tr>
</tbody>
</table>

16 DDR2

There is one “DDR2” memory socket interfaces on the DN9002K10PCI. By convention, the name of this interface is DIMMB. In this section, the interfaces may be called “DIMM”, “SODIMM” or “DDR2” interface interchangeably.

Signal names given in this section, and in other documentation (ucf files) are given in the form DIMMB_<signal name>.

16.1 Power
Each DDR2 SODIMM is capable of drawing 5A of current when in auto-precharge mode.

The DN9002K10PCI is capable of providing this amount of current.

16.1.1 Interface Voltages
The ‘standard’ DDR2 interface voltage is +1.8V. The banks that connect to the DIMM interface are powered by 1.8V, and the power pins on the socket is connected to this same...
power net. In a DDR2 interface, these signals are driven using the SSTL18_DCI drive standard. There are some exceptions, listed below.

**DIMM_SDA, DIMM_SCL, DIMM_CK2**

These signals are connected to a 2.5V clock bank on the FPGA. DIMM_SDA and DIMM_SCL should be driven using the LVCMOS25 standard. For details on the DIMM_C2 signal, see the clocking section below.

The DIMM interfaces are not designed for hot-plug.

### 16.1.2 Changing the DIMM voltage

If you need to change the voltage of the DIMM interface, there is a set of jumper points provided for each interface allowing power to be redirected from a source other than the on-board 1.8V power supply. When the DN9002K10PCI is shipped, a jumper is installed connecting the DIMM/FPGA Bank power to the 1.8V power rail. Next to each of these jumpers is a 2.5V test point suitable for jumping to the DIMM power rail, if necessary. Some Dini Group products (DNSODM_SDR, DNSODM_DDR1) require this jumper to be installed. When installing this jumper, remove the 1.8V jumper to prevent shorting 1.8 and 2.5V supplies together.

For example, to change the DIMM interface to 2.5V, remove the jumper installed in TP12 and install a jumper from TP12.2 to TP13.1

### 16.2 Clocking

The data signals in the DDR2 interface are clocked source-synchronously. In order to clock in and out the “DQ” data signals, the DQS signal is used as a clock using the Virtex-5 “BUFIO”
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clock driver. Details on how to implement a DDR2 controller are in the Xilinx application note XAPP858. You can also see the provided DDR2 reference design for example code.

A basic block diagram of the clocking is given below.

![Block Diagram](image)

Note that the DIMM_CK2 signal is driven by the FPGA from a 1.8V bank. The output should be a DIFF_SSTL18. It is received by a global clock (“GC”) pin on the Virtex-4 device. To receive the signal, use an LVDS_EXT input with DIFF_TERM attribute set to TRUE.

The CK0, CK1 and CK2 signals are length-matched, so this input should be synchronous to the clock input of the DIMM module.

The DQ and DM signals are synchronous to the DQS signals in each bank. See the DDR2 SODIMM module specification for information on the timing of this interface.

DQS timing

In order to clock the DQ and DM inputs using the DQS signal, you must use a BUFIO clock buffer on the DQS signal.
16.3 Signaling

16.3.1 Standards

DQ, and DM signals should use the SSTL18_II_T_DCI drive standard. The required VREF, VRP and VRN connections required for this standard are provided on all DIMM interface banks.

DQS signals should use the DIFF_SSTL18_II drive standard. External differential termination is provided on these signals at the FPGA.

DDR2 clock signals should be driven by the DIFF_SSTL18_II standard.

DDR2 “Control” signals (Address, BA, S#, RAS#, CAS#, WE#) should be driven by the SSTL18_I_DCI standard. The following signals are exceptions to this requirement. On four of the DIMM interfaces, external termination resistors are provided. The signals with external termination are listed below.

- DIMMB_A00
- DIMMB_A01
- DIMMB_A02
- DIMMB_A03
- DIMMB_A04
- DIMMB_A05
- DIMMB_A06
- DIMMB_A07
- DIMMB_A08
- DIMMB_A09
- DIMMB_A10
- DIMMB_A11
- DIMMB_A12
- DIMMB_A13
- DIMMB_A14
- DIMMB_A15
- DIMMB_CAS#
- DIMMB_CS#0
- DIMMB_ODT0

For signals in this list, use the SSTL18_II drive standard.

16.3.2 Serial Interface

The SDA and SCL interfaces are connected to 2.5V LVCMOS buffers. External pull-ups are provided on these signals. The address of all DIMMs on the DN9002K10PCI is set to zero.
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16.3.3 Timing
The length matching of the DDR2 interface signals includes all signals except for DIMM_SCL and DIMM_SDA signals.

Due to the source-synchronous clocking techniques used by the DDR2 interface, the delay from FPGA to DIMM should not be needed, but is provided here anyway.

### DIMMB
- **Length**: 90mm
- **Delay**: 510ps

The trace impedance to each of the connectors is controlled to 50-ohms. All signals in the interface are ground-referenced. Note that this is contradictory to the recommendations of the DDR2 SODIMM specification.

To increase the setup time available for control signals, modules may be set into T2 mode. In the reference design, the modules are in T1 mode.

**Address Control signals:**

**FPGA:**
- Assume a DCM in system-synchronous mode.
- Worst clock-to-out time of Virtex 5: 3.37 with DCM. No phase-shift.
- Worst setup time: 0.097
- Worst hold time: 0.21

**DIMM:**
- Setup 600ps
- Hold 600ps

**DQ signals:**
- **DIMM:**
  - DQS must be within 350ps of DQ, DM
  - setup 400ps
  - Hold 400ps

- **FPGA:**
  - IDELAY
  - setup –1.23
  - hold 2.14
  - clock-to-out 5.34

16.4 Compatible Modules
The DDR2 interfaces are compatible with standard PC2-2700 or faster memory modules up to a capacity of 4GB. The greatest capacity modules available at print time are 2GB. The interface has been tested with modules with a CAS latency of 3. The interface is characterized to 250Mhz,
although faster designs may be possible. Xilinx is advertising a maximum DDR2 interface for the Virtex-5 of 333 MHz.

The DDR2 memory interface can also be used with SRAM, Flash and other types of memory modules. See the chapter on Ordering Options for a list of compatible memory modules.

The interface implementation on these modules is not provided. The customer must design the memory interface including timing and clocking.

16.5 Test points
Each DDR2 interface exposes five signals as test points, located on the bottom of the PCB right under the SODIMM connector. These signals are DQ0, DQS0p, CK0p, RAS# and CAS#. The test points are labeled in silkscreen. The test points near DIMMA implicitly are part of the DIMMA interface, and so on.
17 FPGA Interconnect.

The point-to-point interconnect on the DN9002K10PCI is designed to operate at the maximum switching frequency possible on the DN9002K10PCI. The fastest switching standard available on the Virtex 5 FPGA is LVDS. Using this standard on the interconnect of a DN9002K10PCI; we have demonstrated switching frequencies as high as 950Mbs.

A block diagram of the point-to-point interconnect is below.

The interconnect in the above diagram is confusingly described as sets of two busses. Marketing explained why this was, but I forget the rationale now. “DE” is the bus between FPGA D and FPGA E. It contains 120 “p” signals and 120 “n” signals. This means there are 240 total signals between D and E. If you use LVDS and pain the “p” and “n” signals, you would have 120 LVDS signals between these two FPGAs.

The above diagram is only valid when the board is install with only LX330 FPGAs (the largest available size). When any LX220 or LX110 FPGAs are installed, the interconnect available between FPGAs drops significantly. In the “Ordering Information” chapter of this manual, there is a block diagram showing the available features on a board loaded with LX220 or smaller FPGAs. If the board has mixed LX220 and LX330 FPGAs, then the interconnect available between any two FPGAs is the lesser of the signal counts shown in these diagrams.

Each FPGA-to-FPGA interconnect signal is tested at 700Mbs prior to shipping, no matter which speed grade is installed on your board. Higher speeds are possible, given appropriate IO timing methodology and speed grade parts. The theoretical limitation imposed by the DN9002K10PCI is 1.1Gbs, the limit of the Virtex 5’s internal clock network. Dini group has demonstrated speeds up to 0.95Gbs on each pair of interconnect signals.

Information on how to achieve this interconnect switching speed can be obtained by examining the Xilinx application note XAPP855. Other methods of implanting high-bandwidth interconnect are described in XAPP860.

The Dini Group reference design uses an older method designed for Virtex-4.
In a synchronous system between two FPGAs and a DCM in zero-delay mode, the following timing is possible.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock to Out</td>
<td>3.37 NS</td>
</tr>
<tr>
<td>Trace Delay</td>
<td>1.70 NS</td>
</tr>
<tr>
<td>Rise-time adjustment</td>
<td>0.30 NS</td>
</tr>
<tr>
<td>Clock skew</td>
<td>0.20 NS</td>
</tr>
<tr>
<td>duty cycle</td>
<td>0.05 NS</td>
</tr>
<tr>
<td>jitter</td>
<td>0.05 NS</td>
</tr>
<tr>
<td>setup time</td>
<td>1.00 NS</td>
</tr>
<tr>
<td>Min Period</td>
<td>6.67 NS</td>
</tr>
<tr>
<td>Max Frequency</td>
<td>0.15 GHZ</td>
</tr>
</tbody>
</table>

If LVDS is used, make sure to assign the DIFF_TERM attribute to the IBUFDS in the receiver FPGA.

As the frequency of synchronous communication between FPGAs increases, the user must implement more difficult techniques. As a general guide, these techniques are described below.

- **0 MHz**: The user should use the “Pack the IOBs” by using synthesis attributes. The output delay for each output and setup time for each input is a known value.
- **20 MHz**: Use DCMs in each FPGA to eliminate the variation of clock network skew internal to each FPGA. The clock must be free-running.
- **100 MHz**: Use DCMs in each FPGA to eliminate the variation of clock network skew internal to each FPGA. The clock must be free-running.
- **150 MHz**: Use the phase-adjustment feature of the DCM to use the optimal phase for transmit and receive clocks.
- **250 MHz**: Use DDR clocking, and DDR IO buffers.
- **300 MHz**: Use source-synchronous clocking between FPGAs. The clock is driven with the data for each bus. The receiving FPGA uses the clock signal, received on a “CC” pin to clock the IOs in the bus. An IDELAY element on the CC pin input delays the clock with respect to the data by a fixed amount to allow some setup time.
- **550 MHz**: Use the Virtex 5 built in ISERDES and OSERDES modules.
- **600 MHz**: Use Virtex 5 PLL devices to reduce cycle-to-cycle jitter on the clocks.
- **700 MHz**: Individually de-skew each bit using IDELAY elements. Use a training pattern or hard-code the correct delay values for each input.
- **800 MHz**: Use LVDS signal standard.
- **900 MHz**: dynamically de-skew each bit to account for temperature and voltage variation.
- **1+ GHz**: use error-correcting encoding.

Note that for speeds above 550Mhz, you must use the ISERDES and OSERDES modules, adding latency to your interconnect. (At speeds greater than 500Mhz, there is more than one clock-cycle of latency in board trace delay alone).
For the maximum bandwidth, use single-ended signaling at 700Mhz. For single-ended signaling, an IOSTANDARD of LVCMOS25 is appropriate. Use a drive strength of 6mA or 8mA.

18 Main bus

Main Bus is the interface that the DN9002K10PCI uses to bring USB and PCI access to both of the Virtex-5 FPGAs. If you want to use USB in your design, or want PCI access without implementing PCI in FPGA, then you must implement a Main Bus slave in your FPGAs. The reference designs include one such controller, and you are free to use it.

Drive strength.
Please use the highest drive strength IOs available (24mA)

18.1 MB Signals
The DN9002K10PCI, in addition to the dense interconnect available between FPGAs in a point-to-point topology, provides a 36-signal-wide “MB” bus that is connected to both Virtex-5 FPGAs.

These signals are reserved

18.1.1 Disambiguation
The “MainBus” has two meanings. In this document it usually refers to the interface connecting the FPGAs to USB and PCI via the configuration circuitry. It can also mean the group of 36 signals on the DN9002K10PCI that connects both Virtex-5 FPGAs. It just so happens that the “MainBus” interface is implemented using 36 of the “MB* signals”. In this document “MB” will be used when referring to the signals themselves, and “MainBus” when referring to the Dini-Group-defined, 36-signal interface description.
18.1.2 Electrical
The MB signals are fixed at a 2.5V signaling level. LVCMOS25 is an appropriate singling standard. Due to very heavy capacitive loads on the MB signals, you must use drive strength of 24mA to use main bus. DCI should not be used because the signals are not impedance-controlled. Although not required, by convention, data on the MB signals is synchronous to the MB48 clock. In order to use the “Main Bus” interface to communicate with USB or PCI, you must use the MB48 clock. This clock runs at a fixed 48Mhz.

Note that as well as the 36 “MB” signals, there are also 16 signals in the “Selectmap_D[15:0]” that connect to all FPGAs that could be used for user data. Dini Group does not directly support using these signals. If you chose to use these signals, note that the FPGA design can interfere with the programming of FPGAs. You would have to keep the outputs on these signals tri-stated until all FPGA configurations are complete.

18.1.3 Timing
As described above, the MB signals are typically run synchronous to the 48Mhz MB48 bus. This is the highest speed that the MB signals are guaranteed to run using a system-synchronous clocking method. You may be able to achieve performance from FPGA-to-FPGA on this bus as high as 75Mhz, if you adjust input and output clocks and perform a timing analysis. Using LVCMOS25 with a drive strength of 24mA, you can assume there is a 10ns rise time/flight time for signals on this bus.

No length matching is done on the MB signals.

Virtex 5 clock-to-out time: 3.37ns with DCM
Virtex 5 setup time: 0.97ns
Flight time: 10ns (includes rise-time adjustment for capacitive load)
Total: 14.34ns (69 MHz)

The MB* signals are tested at 48 MHz

18.2 Error Codes
The Main Bus interface has no way of signaling an error condition on read requests, but some errors will result in the same sentinel values being returned. Following is a list of these values.

0xABCDABCD: The Main Bus read timed out. (PCI only)
0xDEADDEAD: The Main Bus read times out (USB only). When this condition occurs, a register, accessible as part of the “configuration register” space, gets incremented. In this way, it is possible for a Main Bus access program to verify that a MainBus transaction has succeeded.
0xFFFFFFFF: The PCI bus timed out. This is not a value returned by the DN9002K10PCI. The PCI request was not returned. The QL5064 may not be configured correctly.
0xDEAD5566: This value is returned by the Dini Group reference design as a default value, when a read request is to an address that has no registers associated with it.
0xBABABABA: <unknown. Contact support>

0x12345678: The Main Bus is disabled. This is the default state of the DN9002K10PCI when it powers on. To set the DN9002K10PCI to enable, a configuration register must be written. This behavior is intended to protect users who do not wish to implement Main Bus interface, but who wish to use the MB0-MB35 signals for their own purposes.

### 18.3 FPGA Interface

All memory-mapped transactions in the reference design occur over the MB bus. This 36-signal bus connects to all Virtex 5 FPGAs and to the Spartan 3 configuration FPGA. The Configuration circuit (Spartan 3) is the master of the bus. All access to the MB bus (reads and writes) is initiated by the Spartan 3 FPGA when the reference design is in use.

![FPGA Interface Diagram]

All transfers are synchronous to the USB_CLK (or SYS_CLK) signal. This clock is fixed at 48 MHz, and cannot be changed by the user. This clock is LVCMOS, single-ended. When the configuration circuit asserts the ALE signal, the slave device on the bus (the FPGA) is required to register the data on the AD bus. This is the “main bus address”. All future transfers over the main bus are said to be at this address, until a new address is latched. On a later clock cycle, the master may assert the “RD” signal. Sometime after this, (within 256 clock cycles), the FPGA should assert DONE for one clock cycle. On this cycle, the master (Spartan) will register the data on the AD bus, and that will be the read data. If DONE is not asserted, then a timeout will be recorded and the transaction cancelled.

Here is a write transaction:
HARDWARE

When the Spartan asserts the “WR” signal, the FPGA should register the data on the AD bus.

Sometime after this, the FPGA should assert the DONE signal. This will allow the Spartan to begin more transactions. The FPGA may delay this for up to 256 clock cycles before a timeout is recorded and the transaction is cancelled.

Main bus can be controlled from the USB Controller program. (Read and write single addresses, or to/from files) It can also be written from the main.txt configuration method. The main.txt syntax is

MAIN BUS 0x<address> 0x<data>

Where <address> and <data> are 8-digit (32-bit) hexadecimal numbers.

18.3.1 Conventional Memory map

By convention, FPGAs on the main bus interface are assigned address ranges. Assigning address ranges is required because the “FPGA sourced” signals (DONE) need to be driven by only one FPGA at a time.

The convention that Dini Group uses is to reserve the upper four bits in the address as an FPGA-select address. The address range (hex)
0x00000000 – 0x0FFFFFFF is reserved for FPGA A
0x10000000 – 0x1FFFFFFF is reserved for FPGA B
and so on.

The user need not follow this convention, but unless you really need 32-bit addresses, we recommend using it. Only one FPGA has “control” of the DONE signal. If the last address latched by ALE was not for a given FPGA, it should tri-state the output. Before tri-stating any
signal with a pull-up or pull-down resistor, it is good practice to drive the signal to the DC value before tri-stating. (So that simulation will match emulation result).

19 Ethernet

An Ethernet interface is available to FPGA B. It is provided by a Vitesse VSC8601 tri-mode Ethernet PHY. The RJ45 connector can be used to connect to a regular 10Base-T, 100Base-TX, or 1000Base-T Ethernet network connection.

The VCS8601 device does not contain an Ethernet MAC. The FPGA must implement a complete network stack to make use of the Ethernet connection. Sorry! I know that’s retarded, and the DN10,000K10PCI will be better. Until then, check out OpenCores Tri-mode Mac controller

http://www.opencores.org/projects.cgi/web/ethernet_tri_mode/overview

19.1 MII

The 4-bit GMII interface is the only required interface on the PHY device. The EEPROM, MDIO, and other signals are only required if you want to put the PHY into a mode that is not default.

The SMI (MDC, MDIO signals) address is set to 0000. Each Ethernet interface (one for FPGA D, one for F) is on its own SMI interface.

19.1.1 Electrical

The appropriate electrical standard to use is LVDCI_25. In Gigabit mode (default), the MII interface runs at 125MHz, DDR.

The CLK_ETH125. Signal should use the SSTL_II_25_DCI signaling standard.

19.1.2 Timing

The board is designed such that when using a DCM in zero-delay mode on the clock, CLK125_ETH, the interface will meet timing, clocking all IOs on this clock. Alternately, you
can use the CLK_ETH_RX to clock inputs using a BUFIO and clock CLK_ETH_TX on the same clock as the rest of your transmit signals.

By default, the 8601’s internal clock compensation mode is enabled. This causes the timing of the device to be based on a clock that is delayed 2ns from the clock on the external TX_CLK and RX_CLK pins. This makes synchronous operation of the interface possible.

Length-Matched: 500ps

FPGA:
Assume a DCM in system-synchronous mode.
Worst clock-to-out time of Virtex 5: 3.37 (with DCM) No phase-shift.
Worst setup time: 0.097
Worst hold time: 0.21

PHY: (clock measured at PHY pin)
clock-out 2ns
setup 2ns
valid: 1.2ns
The EEDAT and EECLK signals are intended to connect the PHY to an EPROM that would contain configuration settings for the device (LED behavior, MII timing, Link speed, duplex, auto negotiation, etc.). Since the MDIO interface is connected to the FPGA, it is unlikely you would ever use these signals, unless you just like emulating EPROMs on weekends and vacations.

If you do not implement the MDIO interface, then the default settings are used for the device. This includes settings that are specified by multi-level inputs connected to resistors.

The CMODE options of the Ethernet PHYs has been set as follows

CMODE0 – 0100 (8.25K resistor)
CMODE1 – 0000 (0 Ohm resistor)
CMODE2 – 0001 (2.2K resistor)
CMODE3 – 0000 (0 Ohm resistor)

This results in the following settings

ADDR = 00000    MDIO address
CLKOUT = TRUE   Drives the CLK_ETH_125 signal
PAUSE = 00      I don’t know
HARDWARE

DOWNSHIFT = FALSE    I don’t know
SPEED = 00    Gigabit mode
ACTIPHY® = FALSE
SKEW = 11     ETH125 clock
MAC CALIBRATION MODE = 00  ???????

The LEDs on the RJ45 connector are controlled by the PHY. The Amber LED indicates activity and the Green LED indicates link in gigabit. The LED, DS64, located next to the RJ45 connector, indicates link in 100Mbit mode. The 10Mb link LED is not configured.

Hot plug is acceptable on a 1000Base-T connection.

The Ethernet PHY works with the Xilinx Ethernet IP, but only in 10 and 100Mbit modes.

The above schematic clipping is useless but looks cool and technological.

19.2 JTAG
The VSC8601 device is attached to a JTAG chain. The schematic clipping showing this connection is given below.
I don’t know why you would need access to this. It isn’t tested or thought about ever. This JTAG chain does not connect to the FPGA JTAG chain.

**20 EPROM**

A small EPROM (1K) is attached to FPGA B. These devices are intended to store identification data for generating a unique MAC address for the Ethernet interfaces. However, the EPROM can be used for any user-defined purpose requiring static-memory intensive tasks, like remembering your name and birthday.

The interface to the EPROM is a standard IIC at 1.8V. The IIC address of the devices is (binary) 1010 000

The maximum clock speed of the IIC interface is 400 kHz.
The pins used to access the EPROM are given below:

ETH_IIC_SCL AE42
ETH_IIC_SDA AE41

**21 Mictor Connectors**

There are two Mictors, 38-pin connectors on the board for the purpose of using a logic analyzer. If you need to use a logic analyzer, be sure to consider using an embedded logic analyzer instead like ChipScope or Identify. This logic analyzers place-and-route within your design and are more flexible than a stand-alone analyzer.

**21.1 FPGA B Mictor**

J16 is a Mictor connector whose signals all connect directly to FPGA B's IOs. This Mictor can be used for a logic analyzer, as probe points (using a Mictor breakout), or to cable to another system.

By default, the signaling level on the Mictor connector is CMOS, 2.5V. Removing R134 and installing a zero-ohm resistor on R135 can change all the IOs associated with this connector changed to +3.3V CMOS signals instead.
Hot-plugging a Mictor connector is generally safe. When connected to a logic analyzer, signals MICTOR32 and MICTOR33 should be used as trigger signals.

Signals connected to the Mictor are 50-ohm. DCI and SSTL (referenced input) can be used on the Mictor interface.

Note the connector is mixed-voltage. The odd pins 13-37 follow the daughter card's B0 voltage and the even pins 12-38 follow the daughter cards B1 voltage.

### 21.2 MainBus Mictor
A second Mictor connector, on the backside of the board, is connected to the MainBus and SelectMap interfaces of the DN9002K10PCI.
Most of the signals attached to the Mictor are accessible from both FPGAs on the DN9002K10PCI. Since these signals are heavily loaded, this connector is not suitable for high-speed signaling.

The “clock” or “trigger” signals on this connector, CLK_48_MIC and MICTOR_CLK_E are driven at a fixed 48 MHz. If you need to use a logic analyzer, this is the only available trigger.

If you use the signals SELECTMAP_D[7:0] for any purpose other than configuration, care must be taken to prevent the FPGAs from driving these signals before all FPGAs are configured, or else risk interfering with the configuration process.

Some SelectMap control signals are connected to this connector, but are not user-accessible. This connector could potentially be used for configuring daughtercards. You would have to contact us for information about that possibility.

**22 Power**

The power used by the DN9002K10PCI is derived from external 5.0V and 3.3V voltage supplies. The current at these voltages is supplied through the ATX power connector, P2, or the PCI edge connector. The maximum power draws on each of these rails is given below.
22.1 5.0V
The 5.0V rail is used to generate most other voltages on the board. The only places where 5.0V is used directly are the daughtercards, and the cooling fan power connectors.

Below is a list of the maximum power draw of each of the 5.0V loads on the DN9002K10PCI.

<table>
<thead>
<tr>
<th>Rail</th>
<th>Max Current</th>
<th>Uses</th>
<th>5V current</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0V_A</td>
<td>25</td>
<td>Internal FPGA power</td>
<td>5</td>
</tr>
<tr>
<td>1.0V_B</td>
<td>25</td>
<td>Internal FPGA power</td>
<td>5</td>
</tr>
<tr>
<td>1.8V</td>
<td>2</td>
<td>DIMM B</td>
<td>1</td>
</tr>
<tr>
<td>2.5V</td>
<td>9</td>
<td>Spartan 3 (1.2V)</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FPGA IO</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FPGA Aux power</td>
<td></td>
</tr>
<tr>
<td>Daughtercards</td>
<td>10</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>25.5</td>
</tr>
</tbody>
</table>

The total possible power requirement of the DN9002K10PCI is 25.5A on 5.0V (127W). This rate of power dissipation is well beyond the cooling capabilities of the heat dissipation provided. Therefore, the user must limit the power dissipated by his design. More typically, each FPGA would only use 10A, and daughtercards would use little or no power on 5.0V. Under these conditions, the 5.0V power requirement is only 4A (20W).

22.2 3.3V
3.3V is used by the DN9002K10PCI to supply the clock distribution network, the configuration logic (Micro controller and Spartan 3 FPGA), and daughtercard power.

The maximum power requirement for the DN9002K10PCI on 3.3V is 1A. 3.3V is taken directly from the ATX power supply or from the PCI slot.

22.3 2.5V
2.5V power is generated from the 5.0V using a 30A power supply.

22.4 Ground
All ground (0V) voltages on the DN9002K10PCI are shared. A monolithic ground design strategy was used. The nets GND_SHIELD and GND_ANALOG are directly connected to the ground plane.
22.5 Voltage Regulation

22.6 Power Connections

The primary sources of power for the DN9002K10PCI are the ATX power connector and the PCI slot. From these two sources, the DN9002K10PCI draws current at 3.3V and 5.0V. All other voltages on the board are generated.

This connector will work with a standard ATX power supply. Any supply rated above 300W is likely to be suitable for use with the DN9002K10PCI. Some budget power supplies do not regulate 5.0V to within the margin required by the DN9002K10PCI. If the 5.0V power rail drops below 4.6V, then the DN9002K10PCI will automatically reset. The 5.0V and 3.3V rails of this connector are directly shorted to the PCI edge connector’s voltage supply pins.
An auxiliary power connector is provided. It connects to the standard ‘hard drive’ power connector of an ATX power supply. The 5.0V and 3.3V supply pins of this connector are directly shorted to the power supply pins of the PCI edge connector.

When the board is plugged into a PCI slot, it can use up to 25W of power without violating the PCI specification. If the user plans to use more than this amount of power, he should connect the aux power connector. **The user must ensure that the 5V and 3.3V rails supplied by the aux power connector are on the same regulated rail as the ones on the PCI power connector**, or risk back-powering the host computer.

Do not back-power the host.

**22.7 Power Monitors**
The DN9002K10PCI monitors the voltage levels on the board to ensure they are within tolerance. If they fall out of tolerance (above or below voltage) the board will enter a reset state. These tolerance ranges are listed below.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0V</td>
<td>(0.95 to 1.21)</td>
</tr>
<tr>
<td>1.8V</td>
<td>(1.65 to 3.00)</td>
</tr>
<tr>
<td>2.5V</td>
<td>(2.20 to 2.90)</td>
</tr>
<tr>
<td>3.3V</td>
<td>(2.89 to 4.00)</td>
</tr>
<tr>
<td>5.0V</td>
<td>(3.99 to 6.02)</td>
</tr>
</tbody>
</table>

The voltage monitors filter the voltage at a frequency of about 1KHz.

The following voltages are not monitored.

- 1.2, VCCO_B0, VCCO_B1, VCCO_B2, DIMM_VTT, DIMM_VREF
When a power supply voltage falls out of tolerance, the board is put in reset (the SYS_RST# signal is asserted), and SYS_RSTn LED glows, and an LED along the right hand side of the board will light to indicate which power rail has failed.

The voltage levels are measured with a RC filter “time constant” of around 1KHz. This means transient voltage spikes may not trigger a board reset.

**22.8 Heat**

The maximum power dissipation supported for each FPGA is 25W. Using the provided heat sink and fan assemblies, FPGAs will remain under the maximum recommended junction temperature (85 degrees C). If your design exceeds this limit, you can assume the temperature of the device rises 2 degrees for each watt above this amount your design uses. Put this number in the settings of the timing analyzer.

Power requirements of a design can be estimated using the power estimator tool in ISE 9.1.

For this calculation the board is assumed to be in an ambient temperature of 35 degrees. In a closed computer case, the ambient temperature will increase.

**22.8.1 Fans**

The fan units attached above the heat sinks are powered by 5V. Each fan has its own power connector.

**22.8.2 Removing Heatsinks**

The heat sink/fan assemblies are attached using a plastic clip. There is a thermal interface material between the FPGA and heat sink that is slightly adhesive. Forcibly removing the heat sink will not damage the FPGA.

**22.8.3 Fan Tachometers**

Each FPGA fan has a tachometer connected to it for the detection of fan failure. If you intend to use this system in a rack or production system, you may want to monitor the fans.
The fan tachometer inputs (AH16) can be LVCMOS25. The fan will produce 2 rising edges per revolution. You may need to de-bounce the signal if you intend to count the fan frequency.

23 Connectors

This section provides a list of all connectors on the DN9002K10PCI. Items considered “test points”, including the “clock TP” points are listed in the test point section.

23.1 FPGA User Interface Connectors

The following connectors are directly connected to the FPGA, and the user needs to know the interface requirements in detail. All of these connectors should be fully described in the manual section indicated below.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Manufacturer</th>
<th>Part Number</th>
<th>Connector description</th>
<th>FPGA</th>
<th>Manual Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>J2, J1</td>
<td>Lighthorse</td>
<td>LTI-SASF546-P26-X1</td>
<td>SMA Jacks (differential)</td>
<td>A</td>
<td>Clocks</td>
</tr>
<tr>
<td>J16</td>
<td>AMP</td>
<td>2-767004-2</td>
<td>Mictor logic analyzer connector</td>
<td>B</td>
<td>Mictor</td>
</tr>
<tr>
<td>J17</td>
<td>AMP</td>
<td>2-767004-2</td>
<td>Mictor logic analyzer connector</td>
<td>ALL</td>
<td>Mictor</td>
</tr>
<tr>
<td>P5</td>
<td>FCI</td>
<td>84520102LF</td>
<td>MEG-Array 400-pin plug</td>
<td>A</td>
<td>Daughtercards</td>
</tr>
<tr>
<td>P6</td>
<td>FCI</td>
<td>84520102LF</td>
<td>MEG-Array 400-pin plug</td>
<td>B</td>
<td>Daughtercards</td>
</tr>
</tbody>
</table>
23.1.1 Comments
If you have a board with fewer than two FPGAs installed, connectors associated with the missing FPGA will be not be installed.

P2 Connections to this RS232 header are through a 12V buffer

J9,15 Pin 1: GND, Pin 2: 5V, Pin 3: Tachometer

23.2 Non-FPGA User Interface Connectors
The following connectors are not directly connected to FPGA IO, and therefore the user does not need to know detailed information about them. The interfaces relating to these connectors are functionally described in the manual section indicated. The FPGA indicated is used to access the connector’s interface, but is not directly connected to the connector pins.

<table>
<thead>
<tr>
<th>Non-User connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>J12,13</td>
</tr>
<tr>
<td>J14</td>
</tr>
<tr>
<td>J11</td>
</tr>
<tr>
<td>S1</td>
</tr>
<tr>
<td>J7</td>
</tr>
<tr>
<td>X2</td>
</tr>
</tbody>
</table>
T1  Belfuse  0826-1X1T-23-F  RJ45 w/ LEDs  B  Ethernet

J6  NONE  NONE  0.1" pitch mounting positions  Ethernet

P4  NONE  NONE  PCI 64-bit edge connector  A  PCI

J10  Molex  87832-1420  14Pos 2MM header

P3  Samtec  TSM-136-01-T-DV  Dual-row 0.1" RS232 header  RS232

J8  AMP/Tyco  1-641737-1  20-pin Vertical "ATX"  Power

P1  Molex  39-29-9202  4-pin Right angle "Hard drive"  Power

23.2.1 Comments
If you have a board with fewer than 2 FPGAs installed, connectors with missing FPGAs as associated FPGA will also not be installed.

23.3 Not-For-Use Connectors
The following connectors are not intended for use by the user.

Not-for-use Connectors

<table>
<thead>
<tr>
<th>Reference</th>
<th>Manufacturer</th>
<th>Part Number</th>
<th>Connector description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y5</td>
<td>Gompf</td>
<td>93340115</td>
<td>PCI Bracket</td>
</tr>
<tr>
<td>JP1</td>
<td>NONE</td>
<td>NONE</td>
<td>1.8V adjust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.8V adjust</td>
</tr>
<tr>
<td>TP12</td>
<td>Mill-Max</td>
<td>999-11-210-10-0</td>
<td>Jumper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.8V connects to DIMMS</td>
</tr>
<tr>
<td>X1</td>
<td>AMP/Tyco</td>
<td>2-641260-1</td>
<td>8-pin DIP socket</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Used by the DN9002K10PCI to store firmware data</td>
</tr>
<tr>
<td>MP2</td>
<td>CCI</td>
<td>B-250-6-1.5</td>
<td>Board Stiffeners</td>
</tr>
<tr>
<td>MP1</td>
<td>CCI</td>
<td>B-250-6-1.5</td>
<td>Board Stiffeners</td>
</tr>
<tr>
<td>M1-3</td>
<td>NONE</td>
<td>NONE</td>
<td>M3 Holes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mounting Holes</td>
</tr>
</tbody>
</table>

23.3.1 Comments
Y3  The pins of Y3 are part of the “DN9002K10PCI mechanical drawing” in the Mechanical section. The two pins are grounded.

JP1  JP1 can be installed to change the 1.8V power rail on the DN9002K10PCI to 2.5V

TP12  These jumpers connect the DIMM interfaces to the 1.8V rail. They can be removed to change the DIMM voltage
M1-3 These are connected to GND

24 Mechanical

The DN9002K10PCI is larger than the PCI specification allows, and is not guaranteed to fit into any ATX case. It will certainly fail to fit into a rack mount server enclosure. The vertical clearance with the fans installed and the ATX power connector not connector is 30mm. Lower-profile fans are available (14mm) but they may not have enough thermal performance for very power-hungry designs.

Mounting holes are all over the place. These are grounded.

Metal runners are along both edges of the board. These are for ground oscilloscope probe ground clips. You should also handle the DN9002K10PCI by its ground bars to help prevent ESD damage to the FPGAs.
25 Daughtercard Headers

The daughter card expansion capability of the DN9002K10PCI is provided by two FCI ‘MEG-Array’ family connectors. Even though it uses the same FCI connector, it is NOT compatible with the 300-pin MSA standard.

Each daughtercard connector provides 186 signals (plus 4 clocks) to its associated FPGA. The signals can be used with just about any setting of IOSTANDARD, and can be used differentially.
The daughter card interface includes a 400-pin MEG-Array connector, made by FCI. The daughter card header is arranged into three “Banks”, correlating to the banks of IO on the Virtex 5 FPGA. Each of these banks connects to one or more “IO Banks” on the Virtex 5 FPGA. This allows three different sets of voltage or timing requirements to be met on a single daughter card simultaneously. Each Bank on the daughter card is 62 signals.

Other connections on the daughter card connector system include three dedicated, differential clock connections for inputting global clocks from an external source, power connections, bank VCCO power, a buffered power on reset signal.

### 25.1 Daughter Card Physical

The connectors used in the expansion system are FCI MEG-Array 400-pin plug, 6mm, part #84520-102. This connector is capable of as much as 10Gbs transmission rates using differential signaling.

All daughter card expansion headers on the DN9002K10PCI are located on the bottom side of the PWB. This is done to eliminate the need for resolving board-to-board clearance issues, assuming the daughter card uses no large components on the backside.

The “Plug” of the system is located on the DN9002K10PCI, and the “receptacle” is located on the expansion board. This selection was made to give a greater height selection to the daughter card designer.

### 25.1.1 Daughter Card Locations and Mounting

The 400-pin daughter card header is located on the bottom (solder) side near the right side of the board. Each MEG-Array header on a Dini Group product has four standard-position mountain
HARDWARE

holes. The drawing below shows the location of the daughter card header and it’s associated mounting holes.

This view of the DN9002K10PCI daughter card locations is from the top of the PCB, looking through to the bottom side. The Dini Group standard daughter card, DNMEG_OBS400 is compatible with the DN9002K10PCI.

The mounting holes are designed to be used with 14mm, M3 standoffs. Dini Group has available appropriate mounting hardware on request:

**Standoffs (Male-to-Female), Part 1789:**
Harwin R30-3001402
(Mouser 855-R30-3001402)
“M3 x 14mm HEX 5mmA/F Harwin Metric Spacers RoHS: Compliant. Box/100”

**Big Round Nuts, Part 1787:**
LMI HN4600300
“M3 x 0.5mm

**Screws, Part 1788:**
MPMS 003-0005-PH
(Digi-key H742-ND)
“SCREW MACHINE METRIC PH M3x5MM”

With this host-plate-daughter card arrangement, there is a limited Z dimension clearance for backside components on the daughter card. This dimension is determined by the daughter card designer’s part selection for the MEG-Array receptacle.

Note that the components on the topside of the daughter card and DN9002K10PCI face in opposite directions.

**25.1.2 Type 2 Short (400pin Short)**
The daughtercard mechanical provisions on the DN9002K10PCI are for a “type 2 short” daughtercard. The DNMEGOBS-400 is of these dimensions. This standard daughtercard provides headers and Mictor connectors for signal access to the DN9002K10PCI
The mounting hole positions are standard, and the DN9002K10PCI has mounting holes to accommodate these holes. See the diagram in the section above.

25.1.3 Insertion and removal
Due to the small dimensions of the very high speed Meg Array connector system, the pins on the plug and receptacle of the Meg Array connectors are very delicate.

When plugging in a daughter card, make sure to align the daughter card first before pressing on the connector. Be absolutely certain that both the small and the large keys at the narrow ends of the Meg Array line up BEFORE applying pressure to mate the connectors!
HARDWARE

Place it down flat, then press down gently.

The following two excerpts are taken from the FCI application guide for the Meg Array series of connectors.

A part can be started from either end. Locate and match the connector's A1 position marking ("?") for both the Plug and Receptacle. (Markings are located on the long side of the housing.) Rough alignment is required prior to connector mating as misalignment of >0.8mm could damage connector contacts. Rough alignment of the connector is achieved through matching the Small alignment slot of the plug housing with the Small alignment key of the receptacle housing and the large alignment slot with the large alignment key. Both connector housings have generous lead-in around the perimeter and will allow the user to blind mate assemble the connectors. Align the two connectors by feel and when the receptacle keys start into the plug slots, push down on one end and then move force forward until the receptacle cover flange bottoms on the front face of the plug.
Dec 09, 2004
25.2 Daughter Card Electrical

The daughter card pin out and routing were designed to allow use of the Virtex 5’s 1 Gbps general purpose IO. All signals on the DN9002K10PCI are all routed as differential, 50-Ohm transmission lines. Signals can be used as single-ended also. Proper electrical levels are explained in the VCCO section.

No length-matching is done on the PCB for daughter card signals, (except between two ends of a differential pair), because the Virtex 5 is capable of variable-delay input or output using the built-in IDELAY or ODELAY modules.

25.2.1 Pin assignments

The pin out of the DN9002K10PCI expansion system was designed to reduce cross talk to manageable levels while operating at full speed of the Virtex 5. The ground to signal ratio of the connector is 1:1. General purpose IO is arranged in a GSGS pattern to allow high speed single-ended or differential use. On the DN9002K10PCI (host), these signals are routed as loosely-coupled differential signals, meaning when used differentially, they benefit from the noise-resistant properties of a differential pair, but when used single-ended-ly, do not interfere with each other excessively.

All high-speed signals on the DN9002K10PCI, including daughter card signals, are routed against a ground potential reference plane. When creating a daughter card, it is recommended that these signals remain against a ground plane to maintain trace impedance.

The central columns of the connector pin out use a closely coupled, differential pair pin arrangement, which is uniformly surrounded by ground pins.

Below is a graphic representation of the pin assignments for the 400-pin connectors. Note that this is a view from the backside of the connector. The green boxes represent ground connections.
Special purpose pins are described below.

### 25.2.2 CC, VREF, DCI
Some of the signals connected to the daughter card expansion headers are “clock-capable”; the inputs on the Virtex 5 FPGA can be used for source-synchronous clocking. In the schematic and customer netlist on the user CD, these pins contain a “_C” in the pin name.

Pins declared in the above diagram that are underlined are connected to “VREF” pins on the Virtex 5 FPGA. These FPGA pins are used to supply a voltage reference used as the threshold voltage for the signals on that bank. The use of these pins is only necessary when using threshold standards, such as SSTL.

DCI is used on all FPGA IO banks connected to a daughter card header. The reference resistance is 50 Ohms. Each Virtex 5 bank that is connected to a header DCI is enabled.

### 25.2.3 Global clocks
The daughter card pin out defines 6 clock output pins. These clock outputs are intended to be used a 3 differential signals (LVDS). Two clock signals GCA and GCB connect to the “GC” clock inputs on the FPGA. These clocks can be used only by the FPGA that is associated with the header.

The GCC signal driven from each FPGA connects to a global clock buffer and can be used by all of the FPGAs on the DN9002K10PCI. (EXT0 and EXT1 networks). Since daughter cards
E and F share the same clock network (EXT1), only one of these two daughtercards can drive a global clock at one time.

25.2.4 Timing and Clocking
Signal from the FPGAs to the daughtercard connector are not length-matched. The maximum trace length on the DN9002K10PCI board for these signals is 800ps.

Each daughtercard has a global clock output pair “DCCLKp/n”. This LVDS output is distributed on the DN9002K10PCI to all Virtex-5 FPGAs. The clock buffer on the host board is designed to deliver the clock edge to all FPGA synchronized with the CCLK pin on the daughtercard header. The daughtercard is expected to distribute clocks on it so that ICs on the daughtercard receive the clock signal synchronized with the pin on the daughtercard header. In this way, the host and daughter boards should be able to communicate synchronously with equal, large IO periods in each direction.

There are three methods of communicating FPGA-to-FPGA across the daughtercard interface.

Local Synchronous
The daughtercard generates a clock and drives it over the GCAp/n or GCBp/n clock pins to the host board FPGA. The daughtercard drives a synchronized clock to the logic on the daughtercard, adding 0.5ns delay to account for the trace delay on the DN9002K10PCI. The host FPGA will use a DCM in zero-delay mode, and the logic on the daughtercard should have a low clock-to-out and setup times. (or use a DCM). This method has the disadvantage of only allowing the one FPGA attached to the daughtercard to use this frequency. To communicate globally across the DN9002K10PCI, the user would have to pass the data across clock domains.

Global Synchronous
The daughtercard generates a clock and drives it over the GCCp/n pins to the DN9002K10PCI host board. The user will select the daughtercard source for either the EXT0 or EXT1 networks as appropriate. The user sets the EXT0 or EXT1 network into zero-delay mode. (contact support@dinigroup.com). The disadvantage of this method is that the EXT0 or EXT1 network must be used, and that the zero-delay configuration has to be calculated for you by us. The advantage is that the entire system can be operated on a single clock domain.

Zero-delay on the DN9002K10PCI is allowed by enabling PLL devices (zero-delay buffers) connected to the GCC pins of each daughtercard header. To allow for a very wide range of clock frequencies sourced from the daughtercard, the PLL bandwidth of these buffers must be manually set. This can be done via USB, PCI or Compact Flash. The PLL can also be bypassed, allowing a global system-synchronous clock to be used without configuring this PLL. To use this method, the user will have to experimentally find the proper clock phase to use on the IO of the daughter card.

Source Synchronous
The daughtercard drives a clock into the CC pins of the daughtercard connector. This clock is used to latch IOs. This method should be used for frequencies exceeding 150Mhz, because the
phase-tolerance of the Virtex 5 FPGA and the clock buffer devices on the DN9002K10PCI EXT0 and EXT1 signals will prevent a reliable system-synchronous design at high speeds.

### 25.2.5 Power and Reset

The +3.3V, +5.0V and +12V power rails are supplied to the Daughter card headers. Each pin on the MEG-Array connector is rated to tolerate 1A of current without thermal overload. Most of the power available to daughter cards through the connector comes from the two 12V pins, for a total of 24W. Each power rail supplied to the Daughter card is fused with a reset-able switch. Daughter cards are required to provide their own power supply bypassing and onrush current limiting.

![Power Supply Diagram](image-url)

The RSTn signal to the daughter card is an open-drain, buffered copy of the SYS_RST# signal. It is also asserted when the User Reset is active. When RSTn is de-asserted, the +3.3V, +5.0V and +12V power rails are guaranteed to be within the DN9002K10PCI tolerance. If there are additional power requirements, the daughter card is required to ensure these.

### 25.2.6 VCCO Voltage

The daughter card is required to provide a voltage on the VCCO pin on the connector. This voltage is used on the DN9002K10PCI to power the FPGA IOs that are connected with that daughter card. In this way, the daughter card can control what voltage the interface will use.

Each bank of the connector (B0, B1, or B2) uses a separate VCCO pin, and can have a different voltage applied to it. When designing a daughter card, you must determine the current requirements for the DN9002K10PCI and supply enough current capacity on these pins.

The VCCO voltage impressed by the daughter card should be less than 3.75 to prevent damage to the Virtex 5 IOs connected to that daughter card.

### 25.2.7 VCCO bias generation

Since a daughter card will not always be present on a daughter card connector, a VCCO bias generator is used on the motherboard for each daughter card bank to keep the VCCO pin on...
the FPGA within its recommended operating range. The VCCO bias generators supply +1.2V to the VCCO pins on the FPGAs, and are back-biased by the daughter card when it drives the VCCO rails.

The output voltage of this regulator can be adjusted if needed. This will require changing the resistors on the ADJ pin of the regulators. The bias regulators can provide up to 1.5A of current. Some low-speed designs may not need more than this. Dini Group recommends placing the IO voltage regulators on the daughtercards, because this does not require modification of the DN9002K10PCI.

### 25.3 Rolling your own daughtercard

Small quantities of the connectors required for building a daughtercard can be obtained at cost from the Dini Group.

If you need help designing a daughtercard, we will be happy to review your schematic for errors. Send it.

### 26 Troubleshooting

#### 26.1 The board is dead

If the board is not responding at all (when connected to a Windows XP computer, there is no “Dini Emulation Engine” in the hardware manager) the board may be stuck in reset. Check the power failure LEDs. If any of them are red, then the board is stuck in reset due to a power problem. If the failing voltage is 3.3V, 5V, or 12V, then the problem is probably caused by your power supply. Check the voltages of these power rails and make sure they are within at least 5% of their nominal voltages. If the power supply was the one supplied by Dini Group, make sure that the voltage trim faceplate is connected. This faceplate allows trimming the 3.3, 5.0 and 12V outputs up and down for performance reasons. If the plate is not connected, all of the power supply's outputs default to their lowest settings. This will cause the Dini Group board to reset due to under-voltage.
If the board is not in reset, the RS232 terminal will be active. Connect a computer serial port to this header and open a terminal program on the computer. Start->Programs->Accessories->Communication->HyperTerminal is a suitable program. We use VanDyke software SecureCRT program, because it doesn’t suck. Hopefully the RS232 configuration status dump will tell you exactly what the problem is. In any case, the Dini Group will need this capture to diagnose the problem.

26.2 The FPGAs won’t program
First, connect the RS232 terminal and follow the instructions in the preceding paragraph. Usually, when an FPGA fails to program, the configuration section will detect the problem and print an error message to this terminal. Common problems the configuration section might report are:

- The syntax in the main.txt file is incorrect
- The bit file on the CompactFlash card is for the wrong type of FPGA
- The CompactFlash card is not formatted with a file system that the DN9002K10PCI can read

If the DN9002K10PCI reports about one or more FPGAs that “DONE did not go high”, then there is a problem with the bit file. The bit file may have been generated using bitgen options that are not compatible with the DN9002K10PCI.

See if the FPGAs will configure using USB, PCI or JTAG.

When you contact Dini Group for support, we will need a capture of the RS232 terminal output.

26.3 My design doesn’t do anything
Make sure that the clock your design uses is running. Output the clock to an LED and probe it with an oscilloscope.

Check the pinout in your constraint file. Check the .PAR report file to make sure that 100% of your IOBs used have LOC constraints. There is never a reason not to constrain an IO.

Use the .PAD report to make sure your constraints were all applied. Some situations may cause constraints to be ignored.

Double-check that the connections match between your FPGA pins and the daughtercard pins using the schematic.

If “MainBus” interface is not working, make sure that none of the other FPGAs are driving those MB pins.

Make sure that the "Unused IOBs" option in bitgen is set to "Float"

Check for Timing errors in the timing report
Route the clock signal to a pin and observe it with an oscilloscope.

26.4 The DCMs won’t lock

1) The DCMs are required to be set in a frequency mode compatible with the frequency of the reference clock input. Check the following attributes of the DCMs.

DFS_FREQUENCY_MODE

2) All clock inputs of the DCM are required to be stable for a certain number of microseconds before releasing the DCMs reset signal. If you are generating the reference clock from an FPGA (or another DCM), you will need to build a delayed-reset circuit to reset the second DCM.

3) Make sure the global clock you are using is being received with an LVDS receiver, not a single-ended one. Make sure the DIFF_TERM attribute is turned on. (especially is the problem is with high-frequency clocks)

26.5 The board resets, right after I didn’t hit the reset button.

Make sure you are meeting the minimum load requirements of the power supply. You may need to connect an old hard drive to one of the 4-pin connectors to draw the minimum 12V load. (DN9002K10PCI uses zero amperes).

Also check that the 5V and 3.3V voltages on the DN9002K10PCI are close to their nominal voltages. If they droop too low, the DN9002K10PCI will detect this and reset. (These two voltages are generated by the external power supply.) Dini Group has found that while some, cheaper ATX power supplies are outputting high currents, even though they are within their limits, the voltage regulation gets sloppy. Power supplies advertised as rated “250W” or greater are generally acceptable.

26.6 The _____ signal on my board is going crazy on my oscilloscope

Make sure the ground clip is attached to the probe.

If there is an oscillation on the signal near 60Hz, there is a problem with the oscilloscope setup.

Capture the oscilloscope view and email it to support@dinigroup.com.
The Reference Design

This chapter introduces the DN9002K10PCI Reference Design, including information on what the reference design does, how to build it from the source files, and how to modify it for another application.

1 What the reference design does

1.1 Example usage of all interfaces

The reference design helps users by showing them how using each interface is possible. Code is provided as-is, and is intended as proof-of-concept on each interface advertised for the DN9002K10PCI product. The Dini Group warrants only that the DN9002K10PCI hardware is functional and usable. The interfaces that the Dini Group design exercises and provides examples for are:

- Access to the DDR2 SDRAM Modules At 250Mhz
- Known-good bitfiles for programming over USB, PCI, CompactFlash or JTAG
- RS232 Communication
- FPGA Interconnect, using IO Flip-flops
- FPGA Interconnect using advanced source-synchronous techniques
- High-Speed PCI (DMA mode to FPGA A)
- Main Bus interface (for USB and PCI communication)
- Main Bus memory-mapping example (to DDR2, block RAM)
- Blink LEDs in cool patterns.
- Reset Button
- New internal Virtex-5 features (PLL, ODELAY, 550Mhz clocking, 800Mbs IO)
- Daughter Card (Test module only)
- Set global clocks
- Ethernet
- Mictor cable (for LVDS communication. Mictor also can be used for logic analyzers)

All source code for the reference design is included on the CD and may be used freely in customer development. Precompiled bit files for the most common stuffing options are also included and can be used to verify board functionality before beginning development. A build
utility, described in the section **Compiling The Reference Design**, can be used to generate new bit files, or to generate bit files for less common configurations of the DN9002K10PCI.

The reference design was created using

Here are the default main.txt file lines.

```plaintext
FPGA A: fpga_a.bit
FPGA B: fpga_b.bit

clock frequency: G0 100Mhz
clock frequency: G1 200Mhz // DDR2 frequency
clock frequency: G2 300Mhz //LVDS test
```

### 1.2 Reference Design Types

“The Reference Design” in this chapter refers to the FPGA designs located on the user CD at

D:\FPGA_Reference_Designs\DN9002K10PCI\MainRef\n
D:\FPGA_Reference_Designs\Programming_Files\DN9002K10PCI\MainTest\n
Four other self-contained designs are on the CD and described in this manual. These four designs are described in their own sections later in this chapter. The remaining sections describe the “MainTest” design. “MainTest”, “The reference design” and “The Dini Group reference design” are the same thing.

The four additional designs are

- **PCI Interface Design**: Tests the 64-bit interface between FPGA A and the QL5064 (PCI)
- **LVDS Reference Design**: Characterizes the FPGA interconnect using source-synchronous
- **Ethernet Reference Design**: Tests the Ethernet PHY.

Other features of the board, such as memory sockets and daughtercard headers are tested using the Main Test.

### 1.3 Using the reference design

Setting the clocks, what the clocks do.

How to run the tests in USB Controller.


## 2 Reference Design Memory Map

The Dini Group reference design memory allows access to the main hardware features of the DN9002K10PCI to the host Main Bus interface. Main Bus can be accessed through PCI or USB. Main Bus is described in the Hardware chapter.

To read this chart:
* Addresses are 32-bits.
* Each address contains one 32-bit word.
* Each FPGA has a base address. FPGA A will respond to all MB accesses in the range 0x00000000 – 0xFFFFFFFF. FPGA B will respond to accesses from 0x10000000-0x1FFFFFFF.
* The addresses given below are offsets from the base address of any given FPGA.
* Base addresses are 0x00000000 for FPGA A, 0x100000000 for FPGA B.
* Some registers are not valid for all FPGAs.
* Some addresses are not valid for all of the Dini Group’s reference designs.
* Some of the address bits are decoded as “Don’t care” bits. Therefore, there may be multiple addresses on Main Bus that access the same registers.

<table>
<thead>
<tr>
<th>Address Range</th>
<th>Register Name</th>
<th>Register Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00000000 - 0x07FFFFFF</td>
<td>DDR2</td>
<td>The data contained in the DDR2 SODIMM memory</td>
</tr>
<tr>
<td>0x080000001</td>
<td>DDR2HIADDR</td>
<td>The upper bits of DDR2 address (MainBus memory space is smaller than most DDR2 SODIMMs)</td>
</tr>
<tr>
<td>0x080000003</td>
<td>DDR2HIADDRSIZE</td>
<td>The number of valid addresses in DDR2HIADDR</td>
</tr>
<tr>
<td>0x080000004</td>
<td>INTERCONTYPE</td>
<td>An ID code used to identify which design is loaded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x34561111 – Interconnect, Single</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x34562222 – Interconnect, LVDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x34563333 – Interconnect, LVDS (reversed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x34560000 – Any Other Design (PCI, Ethernet, etc.)</td>
</tr>
<tr>
<td>0x080000005</td>
<td>DDR2SIZE</td>
<td>A code to control how DDR2 memory is coded into MainBus memory</td>
</tr>
<tr>
<td>0x080000006</td>
<td>RWREG</td>
<td>Read/Write Scratch Register for testing</td>
</tr>
<tr>
<td>0x080000007</td>
<td>DDR2TAPCNT0</td>
<td>The current “tap” settings of the IODELAY elements in the DQ IO buffers on the DDR2 interface (lower bytes)</td>
</tr>
<tr>
<td>0x080000008</td>
<td>DDR2TAPCNT1</td>
<td>The current “tap” settings of the IODELAY elements in the DQ IO buffers on the DDR2 interface (upper bytes)</td>
</tr>
<tr>
<td>Address</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>0x08000000A</td>
<td>This range of addresses is reserved for manufacturing tests (Daughtercards)</td>
<td></td>
</tr>
<tr>
<td>0x080000012</td>
<td>SODIMM_SEL This does nothing on the DN9002K10PCI</td>
<td></td>
</tr>
<tr>
<td>0x080000013</td>
<td>FAN_TACH The current input value of the fan tachometer (0 or 1)</td>
<td></td>
</tr>
<tr>
<td>0x080000014</td>
<td>IS_LX_330 0x1 if the FPGA is an LX330, 0x0 is it is not.</td>
<td></td>
</tr>
<tr>
<td>0x08000001B</td>
<td>SODIMM_RANK Data read from the SODIMM IIC interface</td>
<td></td>
</tr>
<tr>
<td>0x08000001C</td>
<td>SODIMM_COL -</td>
<td></td>
</tr>
<tr>
<td>0x08000001D</td>
<td>SODIMM_ROW -</td>
<td></td>
</tr>
<tr>
<td>0x08000001E</td>
<td>SODIMM_BANK -</td>
<td></td>
</tr>
<tr>
<td>0x08000001F</td>
<td>SODIMM_CAS -</td>
<td></td>
</tr>
<tr>
<td>0x08000021</td>
<td>CLK_COUNTER Contains contents of G0 counter /4</td>
<td></td>
</tr>
<tr>
<td>0x08000022</td>
<td>CLK_COUNTER Contains contents of G1 counter</td>
<td></td>
</tr>
<tr>
<td>0x08000023</td>
<td>CLK_COUNTER Contains contents of G2 counter</td>
<td></td>
</tr>
<tr>
<td>0x08000024</td>
<td>CLK_COUNTER Contains contents of CLK48 counter</td>
<td></td>
</tr>
<tr>
<td>0x08000032</td>
<td>RCLK_COUNTER LVDS source-synchronous clock counters (LVDS design only)</td>
<td></td>
</tr>
<tr>
<td>0x08000033</td>
<td>MCLK_COUNTER Clock counters for (in backwards order!): DDR2 clock,</td>
<td></td>
</tr>
<tr>
<td>0x0800003F</td>
<td>EXTCLK0, EXTCLK1, SACLCLK, CLK_FBE, CLK_FBB, CLK125_ETH, CLKP, CLKP_Tp</td>
<td></td>
</tr>
<tr>
<td>0x08000040</td>
<td>DDR2TESTTAPCNT Reserved for manufacturing tests (DDR2)</td>
<td></td>
</tr>
<tr>
<td>0x08000043</td>
<td>LED_OE Controls LED output enables.</td>
<td></td>
</tr>
<tr>
<td>0x08000044</td>
<td>LED_OUT Controls LED output values.</td>
<td></td>
</tr>
<tr>
<td>0x08000046</td>
<td>DDR2SIZE_SODIMM2 Controls address mapping order on second DIMM interface</td>
<td></td>
</tr>
<tr>
<td>0x08000047</td>
<td>HIADDRSIZE_SODIMM2 Number of unique addresses in HIADDR for second DIMM</td>
<td></td>
</tr>
<tr>
<td>0x0800004B</td>
<td>SODIMM2_RANK IIC data retrieved from the SODIMM in socket 2</td>
<td></td>
</tr>
<tr>
<td>0x0800004C</td>
<td>SODIMM2_COL (FPGA C only)</td>
<td></td>
</tr>
<tr>
<td>0x0800004D</td>
<td>SODIMM2_ROW -</td>
<td></td>
</tr>
<tr>
<td>0x0800004E</td>
<td>SODIMM2_BANK -</td>
<td></td>
</tr>
<tr>
<td>0x0800004F</td>
<td>SODIMM2_CAS -</td>
<td></td>
</tr>
<tr>
<td>0x0800007E</td>
<td>VRP_ALL Contains input signals on the “VRP” pins</td>
<td></td>
</tr>
<tr>
<td>0x0800007F</td>
<td>VRN_ALL Contains input values on the “VRN” pins</td>
<td></td>
</tr>
<tr>
<td>0xB000000</td>
<td>BLOCKRAM The contents of an internal-FPGA block RAM</td>
<td></td>
</tr>
</tbody>
</table>
0x0C00XX0  BUS XX OUT  XX can be 0-21 hex. Output status of IOs on bus XX.
0x0C00XX4  BUS XX OE  XX can be 0-21 hex. OE status of IOs
0x0C00XX8  BUS XX IN  XX can be 0-21 hex. The input values
0x0C00XXC  BUS XX Name  A unique name of the bus (schematic)
0x0xxxxxx  REG_DEFAULT  0xDEAD5566
Any undefined register

3 Interconnect (DC)

The “single-ended” interconnect test tests the DC connectivity of FPGA-to-FPGA interconnect, and the “MB” signals.

Presented on the MainBus, are registers allowing the interface to control the output value, output enable, and input value of each FPGA-to-FPGA interconnect pin. Each pin on the FPGAs is pulled high. This allows a test program to find single-stuck-at faults, open faults, and stuck-together faults.

3.1 Using the Design

The design can be controller over the MainBus. The register banks connected to the IO are arranged into “busses”. Each bus has an ID code, an OE register bank, an ENABLE register bank, and an IN register bank.

The addresses of the IO registers are as follows:

FpgaNum (4-bit) | MB_SEL_INTERCON (4 bit) | busnum (20-bit) | reg_offset (4-bit)

FPGA NUM is 0x0 for FPGA A, 0x1 for FPGA B, 0x2 for FPGA C…
MB_SEL_INTERCON is 0xC
busnum is any number, but only low-values (less than LAST_ADDR) will constrain valid busses
reg_offset is 0x0 for REG_OUT, 0x4 for REG_OE, 0x8 for REG_IN, and 0xC for REG_ENABLED

To determine which bits (if any) in a bus are valid, read the REG_ENABLED register. The 32-bits returned ‘1 are a mask for which of the bits in the REG_OUT, REG_OE, and REG_IN registers are meaningful.

To get the bus ID of a bus, write value 0x1 (32-bit) to REG_ENABLED, then read REG_ENABLED, then write 0x0 (32-bit) to REG_ENABLED. The value returned will be a coded name for the bus. Bits 0-15 are ASCII characters representing FPGA names. Bits 16-31 are an arbitrary unique integer distinguishing the bus. Connecting busses from two different FPGAs have the same bus ID.

To cause an FPGA to output signals on a bus, write 0xFFFFFFFF on REG_OE. To set the outputs all to “high” write 0xFFFFFFFF to REG_OUT.
To read the current received value from the bus' inputs, read from REG_IN

3.2 Running the Test
In the USB Controller program, select Settings->OneShot Test. From the dialog box, check the Interconnect Test box. The program will automatically load the bit files, set the clocks and run the test.

4 DDR2 Interface
The DDR2 interface design is an example DDR2 controller running at 250Mhz. You can use this controller as an example, especially for the purpose of required IO logic, timing and clocking. The bandwidth of the controller most DDR2 bandwidth possible on the DN9002K10PCI.

4.1 Provided Files
The DDR2 reference design is part of the “MainTest” reference design, and the MainTest files should be used.

4.2 Using the Design
The DDR2 memory interfaces are mapped to the address range

0xNXX00000 – 0xNXXFFFFF

Where the 4-bit “N” represents an FPGA ID, as described in the MainBus interface description. X are “don’t-care”. Since the remaining 19 bits are insufficient to address an entire 4GB DRAM, there is a register DDR2HIADDR that selects the highest address bits of the DRAM. Each address refers to a 32-bit location in the DRAM. The lowest bit is not mapped to DRAM address, but instead selects between the upper and lower 32 bits of the DRAM data. This is necessary because MainBus is a 32-bit interface, and the DN9002K10PCI DRAM interfaces are 64 bits wide.

The bank and side controls are also mapped to the DDR2HIADDR register. The location of the DDR2HIADDR register is given in the Reference Design Memory Map section.

The clock that this design uses (G1) must be set to between 180 and 250Mhz. <verify this number>.

4.3 Running the Test
To run the hardware test, in the USB Controller application, select Settings->OneShotTest and check the DDR2 box. The program will automatically load the bit files, set the clocks and run the test, reporting any errors.
5 Clock Counters

Each clock available to the FPGA is connected to a counter register, and the value of this register is available on MainBus. In this way, the user can determine if each clock input is working properly.

6 LEDs

All of the LEDs are connected to an output enable register. When the LEDs are not enabled, they blink a pattern representing which FPGA the design is for. When enabled, each LED is controlled by the LED value register.

7 Simulating the Reference Design

The simulation environment the Dini Group uses is ModelSim. A ModelSim project file is provided, but it may not be compatible with your version of ModelSim. When you create a ModelSim project, add only the top-level design file (sim_single.v).

Source can be found on the user CD:
D:\FPGA_Reference_Designs\DN9002K10PCI\MainTest\source\*

Also, you must add to the project a simulation library. Simulation models of all of the primitives used in the reference design are found in the Xilinx ISE install directory in the unisims directory.

Simulation models are also provided of the DN9002K10PCI as a whole board, along with DDR2 modules, headers and the MainBus interface.

8 Compiling the Reference Design

The MainTest reference design (for which bit files are included on the user CD and the provided CompactFlash card) can be found on the user CD here.

D:\FPGA_Reference_Designs\*
   \common\DDR2\controller_ver\*
   \ddr2_to_mb\*
   \DN9002K10PCI
       \MainTest\source\*

The top module is

D:\FPGA_Reference_Designs\DN9002K10PCI\MainTest\source\fpga.v

This module includes all of the other required sources and expects the directory structure found on the CD.
8.1.1 The Xilinx Embedded Development Kit (EDK)
The DN9002K10PCI does not use the EDK because it has no embedded processor.

8.1.2 Xilinx XST
The Dini Group uses XST software to for design synthesis. The XST projects for each of the 3
FPGAs on the DN9002K10PCI can be found at ‘buildxst/*.xst’. These projects have been
create and tested using XST version 9.1.

8.1.3 Xilinx ISE
Xilinx ISE version 8.2 (service pack 3 or later) is required to use the DN9002K10PCI. Earlier
versions may work, but are not supported. Use HDL files as input. Modification of the ISE
project may also require modification of the HDL, timing constraints are in files ‘buildxst/*.xcf’.

8.1.4 The Build Utility: Make.bat
The Build Utility is found at ‘DN9002K10PCI/build/make.bat’. This batch file can be used to
run ISE and bitgen. You may need to run make.bat from inside of a Cygwin session because the
script runs the program sed. You may also need to add the Xilinx bin directory to your path so
the command “par” calls the correct program.

The build script creates a directory called “out” and places its output files there. After the script
completes you will find files for each FPGA that was built. fpga_*.bit is the file to be
downloaded to the FPGA.

8.2 Bitgen Options
The Make.bat script correctly sets all bitgen options that are compatible with the
DN9002k10PCI. The following options should be used with the DN9002K10PCI. Options
that are not listed here can be selected by the user, or left to their default settings.

Compress: OFF (Or you can disable “sanity check” option on board)
UnusedPin: Pullnone
Persist: Yes (Only require is Readback is used)
Encrypt: No (Or you can disable “sanity check” option on board)
DonePipe: No (“Yes” Can cause configuration errors)
DriveDone: Yes (“No” can cause configuration Errors)

Don’t ever disable “CRC Check”. This is the easiest and most certain way to turn your FPGAs
into little piles of carbon ash. I am pretty sure this option exists to increase sales of replacement
FPGAs.

8.3 VHDL
Placeholder for VHDL source code. Contact support@dinigroup.com
9 LVDS Reference Design

The "LVDS Intercon" design is to show the user how to implement source-synchronous communication between FPGAs. Using this method, the advertised 800Mbs system speed can be achieved. If you do not wish to use source-synchronous interconnect, ignore this reference design.

All FPGA-to-FPGA interconnect in this design is constantly being driven by one FPGA sending (uni-directionally) a test pattern. The receiving FPGA checks the test pattern for correctness against a known pattern.

The design is intended to characterize the bandwidth of the interconnect between FPGAs. Access to test status is provided over the MainBus interface.

Note that there are two designs, “ADC” and “CBA”. In the design, the directions of LVDS connections between FPGAs are uni-directional. In the “CBA”, all of the signals are in a direction opposite to the “ABC” design signals.

9.1 Provided Files

The source is located at:

D:\FPGA_Reference_Designs\DN9002K10PCI\MainRef

Note that this is the same source as the “Main Reference Design”. To compile the design for LVDS, #define statements in the Verilog code must be added or removed. The make.bat utility described in the “compiling the reference design” section automatically adds and removes these directives. The pre-compiled bitfiles for this design are located at

D:\FPGA_Reference_Designs\Programming_Files\DN9002K10PCI\LVDSIntercon\n
9.2 Using the Design

The design’s MainBus interface is undocumented

The IOs in the LVDS reference design are clocked using the G0 clock. A clock setting of 300Mhz on G0 results in data transmission from FPGA to FPGA of 600Mbs per signal pair.

9.3 Running the Test

In the USB Controller program, select Settings->OneShot Test. From the dialog box, check the Interconnect Test box. The program will automatically load the bit files, set the clocks and run the test.

10 PCI Interface Reference Design

The PCI reference design is an example of how to use the provided QL5064_module_interface module provided.
10.1 Provided Files

10.2 Using the Design
The PCI reference design maps internal FPGA block rams to BAR 1 through BAR6 of the FPGA’s PCI interface, and a separate block ram to the DMA channel of the PCI interface. When the design in loaded in the FPGA, a host machine can read and write to this memory space to verify the interface is working. Only 4KB of memory is mapped to each BAR, even though the size of each BAR is larger. The block ram memory will wrap.

10.3 Running the Test
The PCI Reference Design is an FPGA A-only design that implements the QL_Interface_Module interface described in the document D:\FPGA_Reference_Designs\DN00k10PCI\PCI_interface\QL5064_Interface_Module.pdf

This design implements a PCI target access and DMA interface to a block ram inside FPGA A. The source code is located on the CD at:

D:\FPGA_Reference_Designs\DN9002K10PCI\PCI_interface\Blockram_Access_A\source

The pre-compile bitfiles for your board are located at:

D:\FPGA_Reference_Designs\Programming_Files\DN9002K10PCI\PCI_Interface\source

In this design, accesses to BAR2, BAR3, BAR4, BAR5 and both DMA channels are mapped to separate block rams in the FPGA. Upper bits of the address offset are ignored, so the block ram loops around. To use this design, see the PCI section of the hardware chapter.
Chapter 6: Ordering Information

Part Number
DN9002K10PCI

1 Section Title

Request quotes by emailing sales@dinigroup.com.

For technical questions email support@dinigroup.com

2 FPGA Options

Any subset of FPGAs can be installed on the DN9002K10PCI. Any unneeded FPGA positions can ship empty to reduce the total price.

2.1 FPGA A and B:
Select an FPGA part to be supplied in each position, A-F. Possible selections are

NONE
LX110 –1 –2 –3
LX220 –1 –2 –3
LX330 –1 –2

2.2 CES Parts
The DN9002K10PCI may ship with CES “engineering sample” parts. This is often the case early in the Xilinx product release cycle. If your board will ship with CES parts, the quote will state the Xilinx part number of each FPGA on your board, indicating a CES revision. It is important that the user knows that CES parts may have limitations that are not listed in the Virtex-5 datasheet. To read about these limitations, see the Xilinx website and search for Virtex-5 errata. In general, it is the responsibility of the user to determine if the board is suitable for his application prior to ordering a board. Details about the interfaces on the board that are not in this manual and characterizations of interfaces, if available can be requested.

2.2.1 Hardware Errata Details
This list may not be complete. See the Xilinx website for an up-to-date list
**Block RAM**
1) In simple dual port and cascade mode, the data output register cannot be initialized by configuration (INIT), and it cannot be restored to the INIT register content using the Global Set/Reset (GSR).

2) Violating timing requirements on the address bus can cause the block RAM to cease normal operation until the device is reconfigured. Asynchronous resetting of the block RAM in FIFO mode can cause a similar outcome.

3) FMAX_FIFO is 400 MHz when using the attribute EN_SYN = TRUE.

**Clocks**
1) Only BUFG and BUFGCE are supported. The remaining global clock buffer primitives are not supported.

**OSERDES**
1) Optional inversion for the divided clock (CLKDIV) in the OSERDES is not supported.

**Configuration**
1) Configuration bitstream compression and fallback reconfiguration are not supported.

### 2.3 “Small” FPGAs
The DN9002K10PCI is optimized for two Xilinx Virtex-5 LX330 FPGAs. Optionally, it can be ordered with LX110 or LX220 FPGAs instead. When installed with one or more LX110 or LX220 FPGAs, the amount of available interconnect is reduced due to some IOs in those devices being "no-balled".
The diagram above shows the block diagram representing the resources available on a board installed with two LX110 or LX220 FPGAs. One-third of each daughter card's pins become unusable, and the amount of interconnect between FPGA A and B is reduced from 696 signals to 378 signals.

The Ethernet, PCI and DIMMs are not affected by FPGA selection. Also, you should analyze your design to determine if the internal resources available in the LX110 and LX220 are sufficient to meet your needs. The FPGA selection guide from Xilinx is printed below.
2.4 Speed Grades

The interface performance characterizations included in this manual and in advertisements are valid for all shipped FPGAs, regardless of speed grade. These numbers are characterizations, and not guaranteed under all operational conditions. Every shipped board has passed this characterization test under some operational conditions.

If there are any interfaces where performance is only characterized for specific speed grade parts, this is noted in the advertisement and in this document. Below is a list of all such interfaces:

1) PCI Express

Some interfaces may run at increased speeds above and beyond Dini Group’s advertised performances when used with –2 or –3 speed grade parts. Some performance numbers that are advertised by Xilinx are listed here. These characterizations have not been performed on the DN9002K10PCI, but we have no reason to think the DN9002K10PCI is a limiting factor on these interfaces:

<table>
<thead>
<tr>
<th>Interface</th>
<th>Characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPGA-to-FPGA interconnect, LVDS</td>
<td>1.25 Gbs (625 MHz)</td>
</tr>
<tr>
<td>FPGA-to-FPGA interconnect, single-ended</td>
<td>800 Mbps (400 MHz)</td>
</tr>
<tr>
<td>DDR2 Interface</td>
<td>667 Mbps (333 MHz)</td>
</tr>
</tbody>
</table>
2.5 Upgrade Policy
Upgrading (adding FPGAs) to a DN9002K10PCI.

Call for a quote.

3 Optional Equipment
The following tools are suggested for use with the Dini Group DN9002K10PCI.

3.1 Compatible Dini Group products
The Dini Group supplies standard daughtercards and memory modules that you can use with the DN9002K10PCI.

3.1.1 Memories
The memory module solutions from Dini Group allow the user to install whichever type of memory his application requires.

- DNSODM200_SRAM
  Memory module for use in the 200-pin SODIMM sockets.
  Standard memory configuration: Two GS8320V32 memories (1M x 32 each)
  Performance up to 175Mhz (SDR)
  Small EPROM.

- DNSODM200_QDR
  QDR SRAM module, compatible with the DDR2 SODIMM sockets.
  Two times 32 bit wide
  Small EPROM.

- DNSODM200_NOBL
  Cypress “no bus latency” SRAM (64 bit wide)
  Compatible with 200-pin SODIMM sockets
  Ask for availability.
  Small EPROM.

- DNSODM200_RLDRAM
  Reduced latency DRAM (Micron) 64 bit wide
  compatible with the 200-pin SODIMM sockets.
  Small EPROM.

- DNSODM200_MICTOR
  Provides 2 Mictor-38 connectors.
  Compatible with the DDR2 SODIMM sockets.
  User LEDs. Small EPROM.
ORDERING INFORMATION

- **DNSODM200_DDR1**
  DDR1 memory module compatible with the 200-pin SODIMM sockets
  (Jumper rework required)
  Comes with 512MB standard.
  Allows use of standard PC2700 modules (up to 1GB)
  175Mhz performance

- **DNSODM200_SDR**
  SDR memory module compatible with 200-pin SODIMM sockets.
  Accepts PC133 modules up to 512MB.
  (Jumper rework required)
  Comes with 256MB standard.
  75Mhz performance

- **DNSODM200_FLASH**
  Spansion S29WS064J memory (x2). Each is 4Mx16 bit flash
  16Mb SRAM memory (512k x 32)
  Compatible with DDR2 SODIMM sockets.
  66Mhz performance (read burst)

3.1.2 Extenders

- The DNPCIEXT-S3/5 is an extender card designed to aid in the debug and test of PCI-based circuit boards. This is an active extender card; an Intel® 21154 PCI to PCI bridge is used to isolate the primary PCI bus from the three secondary PCI bus slots. Since primary and secondary busses are electrically isolated, a much cleaner electrical signaling environment exists, and a single host slot can be expanded to contain up to three plug-in PCI cards. The primary PCI frequency can range from 0 to 66.66 MHz. The secondary PCI frequency is configurable to be the primary frequency or one half the primary frequency. DIP switches are provided to force the primary or secondary busses to 33MHz.

3.1.3 Daughtercards

Dini Group daughtercards connect to the MEG-Array connector (400-pin) using the standard Dini Group interface description.

- **DNMEG_PCIE**
  8-lane PCI express PHY card. Host or downstream mode.
  DDR2 memory module.
  Virtex-4 FPGA. (LX40-LX160)

- **DNMEG_ADC**
  High-speed Analog-Digital daughtercard
  Virtex-4 FPGA
  DDR2 memory module
  250Mps, 12-bit ADC. 60dB SNR (10 bits) 200kHz-75Mhz
ORDERING INFORMATION

- **DNMEG_ARM**
  ARM processor core development daughtercard
  Altera Excalibur FPGA
  PC133 memory module

- **DNMEG_DDR2 (in development)**
  Two DDR2 memory sockets, (8GB max memory)

- **DNMEG_S2GX**
  Altera Stratix 2 GX FPGA. DDR2 Memory.
  High-speed serial interfaces. SMA, SATA, SFP, others

- **DNMEG_OBS**
  Adjustable-voltage tenth-inch pitch headers
  User LEDs
  Two Mictor-38 connectors.
  SMA global clock inputs for host board.

3.2 Compatible third-party products
The following products have been shown to work with the DN9002K10PCI.

Intel Entry Server board SE7230NH1-E
http://www.intel.com/design/servers/boards/se7230nh1-e/index.htm
Ordering Information

Standard DDR2 modules (256 MB $44, 512 MB $79, 1GB $141, 2GB $722, 4GB eventually)
http://www.crucial.com/store/listmodule/DDRII/list.html

Xilinx Platform USB Cable (required for JTAG FPGA programming, firmware update, ChipScope Pro)
HW-USB-G
http://nuhorizons.com

Mictor breakout
MIC-38-BREAKOUT
http://www.emulation.com/catalog/off-the-shelf_solutions/mictor/

4 Compliance Data

4.1 Compliance

4.1.1 EMI
Since the DN9002K10PCI is not intended for production systems, it has not passed EMI testing. Compliance is only done by special request.

4.1.2 PCI-SIG

4.2 Environmental

4.2.1 Temperature
The DN9002K10PCI is designed to operate within an ambient temperature range of 0 – 50 degrees C.

All components used on the DN9002K10PCI are guaranteed to operate within a temperature range of 0 – 80 degrees C (measured on the device die).

4.3 Export Control

4.3.1 Lead-Free
The DN9002K10PCI meets the requirements of EU Directive 2002/95/EC, “RoHS”. Specifically, the DN9002K10PCI contains no homogeneous materials that:

a) contains lead (Pb) in excess of 0.1 weight-% (1000 ppm)
b) contains mercury (Hg) in excess of 0.1 weight-% (1000 ppm)
c) contains hexavalent chromium (Cr VI) in excess of 0.1 weight-% (1000 ppm)
d) contains polybrominated biphenyls (PBB) or polybrominated dimethyl ethers (PBDE) in excess of 0.1 weight-% (1000 ppm)
e) contains cadmium (Cd) in excess of 0.01 weight-% (100 ppm)

No exemptions are claimed for this product.

4.3.2 The USA Schedule B number based on the HTS
8471 60 7080
4.3.3 Export control classification number ECCN
EARC99

4.4 Mission Critical
DN9002K10PCI and supporting hardware and software are not intended for use on human subjects that you like, in life support, mission-critical systems, or aviation.