Connect Tech Inc.
Embedded Computing Experts

Application Note 00003
Implementing a serial port using the FreeForm/104 with Daughter Board

Introduction

This application note provides instruction on how to implement a standard 16550 based serial port using Connect Tech's FreeForm/104 with the transceiver daughter board attachment.

The FreeForm/104's FPGA is used to implement a Universal Asynchronous Receiver/Transmitter (UART) to translate data between serial and parallel forms. The daughterboard provides the electrical interface for communication standards such as RS-232 and RS-485 (discussed later in the application note).

This application note assumes the reader is familiar with the basics of serial communications, and knows how to properly program the FreeForm/104 board.

IP Information

The UART core used in this project was obtained from the open source hardware IP website OpenCores (http://www.opencores.org), under the project name "A VHDL 16550 UART Core", Copyright (c) 2006, 2007 by H LeFevre. This core extensively uses "The GH VHDL Library", Copyright (c) 2005, 2006, 2007, 2008, 2009 by George Huber. These OpenCores Projects are used with permission from their rightful owners, with any revisions made indicated in the revision blocks in the header of the appropriate source files. Links and useful information regarding these projects are provided in the **Reference and Helpful Links** section.

Functional Description

The 16550D UART core used in this design is intended to be compatible with the National Semiconductor PC16550D UART. This UART is implemented in the FreeForm/104's Spartan 3E FPGA, which communicates with the Daughter board through two vertical digital I/O headers. The daughter board acts as the physical interface for serial data communication. The block diagram shown in Figure 1 gives an overview of the interconnections and basic components.

While this application note details the basics of the configuration and operation of the entire UART module, specifics about the Daughter board, 16550D UART code, and GH VHDL Library can be found in the appropriate user manuals (see **Reference and Helpful Links**).

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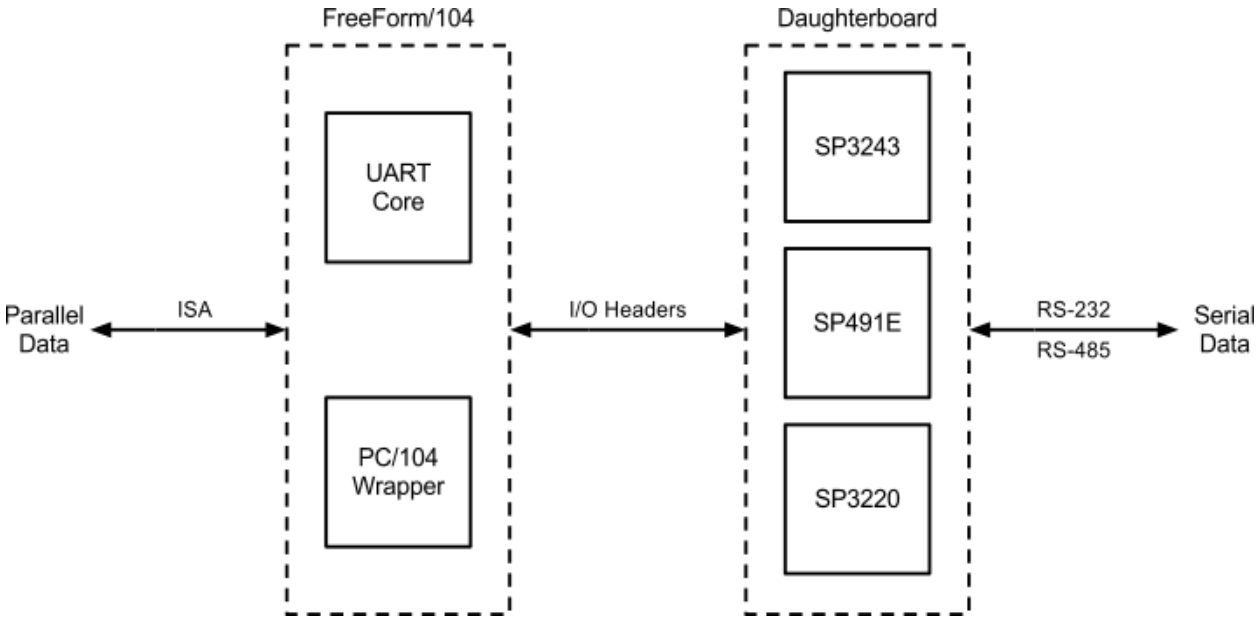

Figure 1: High Level Block Diagram of Communication Interfaces

UART Configuration

Table 1 lists the UART configuration specifics, including all of the information needed when initializing a serial driver to work with this module. In the interest of simplicity and flexibility, only one UART was implemented onto the FreeForm/104, using the default clock frequency of the onboard osciallator. It should be noted, however, that modifications such as changing the input clock frequency and or adding a second UART should be relatively straightforward, following the model of the first.

Table 1: 16550D UART Configuration Specifics

Base Address Offset	IRQ	Clock Frequency (Hz)	Divisor Value	FIFO Enable
0x00	7	66000000	16	Always

Design Implementation

The implementation of the 16550D UART uses VHDL. The design can be easily modified to add a second UART, adjust the input clock frequency, change the IRQ, etc...The operation of the UART is most easily handled with serial drivers, as discussed in **UART Operation**. The VHDL source code and testbench files can be found at http://devel.connecttech.com/freeform104/. Additional links can be found in the **Resources and Helpful Links** section.

UART Operation

Downloading design onto FreeForm/104 board:

1. Download the ctiFreeForm_UART directory, and open the ctiFreeForm_UART.xise project file using ISE Project Navigator.
2. Synthesize, Implement, and Generate Programming File using ISE.

3. The UART_tb.vhd file can be used for simulation with ISim. An example output from ISim of a transmitting a hex value of 0x14 is shown in Figure 2.
4. Use the ctiFreeForm.bit file generated from *step 2*, and a configuration tool such as iMPACT to download the design onto the FreeForm/104 board. Load the flash memory with UART.mcs.
5. TX and RX output pins for the UART are DIO0A[7] and DIO1A[7], respectively, with GND being located at the opposite end of the DIO header (pin 50). On the Daughterboard, output pins are located at pin 1 (GND), pin 3 (TX), and pin 5 (RX) of the appropriate header. Please refer to the user's manual for more information.

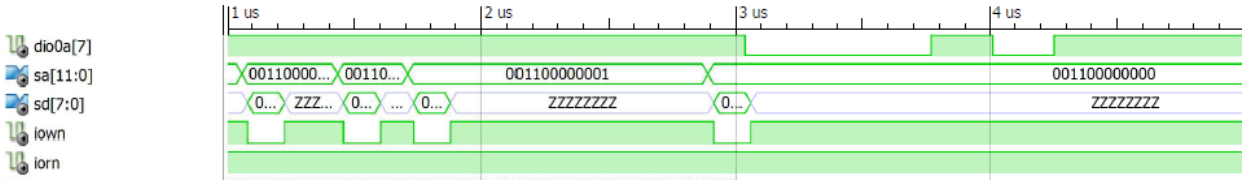

Figure 2: ISim output for transmission of 0x14 using the FreeForm's 66 MHz internal clock and smallest possible divisor value. This example uses 5 data bits, no parity, and 1 stop bit. Output signal for TX is dioa[7].

Testing UART using QNX 6 driver:

1. Connect Daughterboard to FreeForm/104 using vertical headers, and install the FreeForm/104 onto a PC/104 stack or into a PC's ISA slot using an adaptor.
2. Connect serial adaptor to header of Daughterboard, with appropriate pin locations in accordance to RS-232/RS-485 standards.
3. Driver can be loaded using the following:

```
devc-ser8250 –u3 –c 66000000/16 300,7 &
```

4. You should now see **ser3** listed in devices
5. QTALK can be used to test driver:

```
qtalk –m /dev/ser3
```

Testing UART using LINUX driver:

1. Connect Daughterboard to FreeForm/104 using vertical headers, and install the FreeForm/104 onto PC/104 stack or into a PC using ISA adaptor.
2. Connect serial adaptor to header of Daughterboard, with appropriate pin locations in accordance to RS-232/RS-485 standards.
3. Driver can be loaded using the following:

```
setserial /dev/ttyS1 port 0x300 irq 7 baud_base 4125000 skip_test
```

4. You should now see **ttyS1**listed in devices
5. MINICOM can be used to test driver:

```
minicom -s
```

NOTE:

- Only LINUX and QNX are supported.

References and Helpful Links

#	Links
1	Connect Tech FreeForm/104 Product page http://www.connecttech.com/sub/Products/freeform104.asp?l1=fpga&l2=ff104
2	Connect Tech FreeForm/104 Daughter Board Product Page http://www.connecttech.com/sub/products/Daughter_Board.asp?l1=fpga&l2=daughterboard
3	UART Source Code and Documentation http://devel.connecttech.com/freeform104/
4	OpenCores Project “A VHDL 16550 UART Core” http://opencores.org/project,a_vhd_16550_uart
5	OpenCores Project “GH VHDL Library” http://opencores.org/project,gh_vhdl_library
6	PC16550D Datasheet https://www.national.com/ds/PC/PC16550D.pdf