An Efficient Implementation on a Low Cost FPGA for Photon Detection in Nuclear Imaging

November 29, 2010

1 Introduction

This application note describes how to utilize the Xilinx Spartan 3E Starter Kit board along with Digilent's PmodAD1 Analog to Digital Converter (ADC) for photon detection in Nuclear Imaging. The tool was designed using Xilinx's Embedded Development Kit (EDK) and was based in Xilinx's Microblaze soft-core processor[1].

2 System Requirements

2.1 Hardware and Software Requirements

The hardware and software requirements are :

- Xilinx Spartan 3E Starter Kit, Revision D [2]
- Two Digilent's PmodAD1 ADCs [3]
- Four spectroscopy amplifiers
- Xilinx Platform USB Cable
- A crossover ethernet cable connecting the board to a Windows or Linux host with 10/100 compatible NIC
- Xilinx Platform Studio 11.5 (included in ISE design suite 11.5) for running or making hardware modifications
- Xilinx SDK 11.5 (included in ISE design suite 11.5) for running or making modifications to the software

2.2 System set up

1) Install jumpers on J30 pins 1-2 and 3-4 and 5-6 (MODE: M0 and M1 and M2)
2) Install jumpers on J11 pins 1-2 and 3-4
3) Install jumper on JP9 pins 2-3 (3.3V)
4) Install jumper on JP6 pins 1-2

5) Install jumper on JP7 pins 1-2

6) Connect the USB cable between J18 and a USB port on the PC

7) Connect the power supply on J20

8) Connect an Ethernet crossover cable to the board RJ-45 connector and the Ethernet port of the PC

9) Connect the two PmodAD1 ADCs to J1 and J2

10) Set the SW0(L13) slide switch to 1

11) Connect amplified signals to P1 and P3 pins of PmodAD1 J2 connector

12) Configure the host PC with an IP address of 192.168.1.11, with a subnet mask of 255.255.255.0.

2.3 Signals Digitization

The PmodAD1 ADC converts an analog input signal ranging from 0-3.3 Volts to a 12-bit digital value in the range 0 to 4095. The PmodAD1 has two simultaneous A/D conversion channels, each with a 12-bit converter and filter. Each channel can sample a separate stream of analog signals at a rate of 1Msps.

Due to ADC low sampling rate, analog input signals should have certain characteristics :

- Pulse Height ranging from 0-3.3 Volts
- Timing duration ranging from 8-11 usec
- Gaussian shape(optional-recommended)

3 Operating the system

1) Start XPS and open the **system.xmp** project, located in project directory (../Spartan3E_DAQ/hw/XPS_project)

2) In XPS select *Project → Export Hardware Design to SDK...* and click *Export and Launch SDK*

3) Slide the board power switch (SWP) to the ON position

4) Run on the host PC the **server.c**, located in *../Spartan3E_DAQ/sw* directory. Port for communication should be provided as an argument. For this set up, port 2000 should be used. The code is running on linux machines only.

5) In XPS select *Device Configuration* → *Download Bitstream*

6) In SDK select *Run* → *Run...* and run the **TxTest.elf** executable

7) Results will be saved, using hex format, in **results.txt** file produced within **server.c**

8) C++ code for image construction is located in *../Spartan3E_DAQ/sw* directory. Energy and position spectra files are also produced. Seperate codes are provided depending on pulse shape (spartan3e_gauss.cpp for Gaussian pulse shape, spartan3e_max.cpp for **non** Gaussian pulse shape).

References

[1] Eleftherios Fysikopoulos, Maria Georgiou, Nikos Efthimiou, Stratos David, George Loudos and George Matsopoulos, An Efficient Implementation on a Low Cost FPGA for Photon Detection in Nuclear Imaging, *IEEE Nuclear Science Symposium Conference Record*, 2010

[2] "Spartan-3E Starter Kit Board User Guide, Xilinx Inc., UG230(v1.1) June 20, 2008", datasheet available online at http://www.xilinx.com

[3] "Digilent PmodAD1TM Analog To Digital Module Converter Board Reference Manual, 2005", datasheet available online at http://www.digilentinc.com