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Sensor data acquisition for scientific grade cameras

Piotr Zdunek

Numer albumu 229417

promotor
Dr inż. Grzegorz Kasprowicz

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Politechnika Warszawska
Warsaw University of Technology

…………………………...
miejscowość i data
place and date

Piotr Zdunek
imię i nazwisko studenta
name and surname of the student

229417
numer albumu
student record book number

Elektronika
kierunek studiów
field of study

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Tytuł: Akwizycja danych z czujników optycznych dla kamer do zastosowań naukowych

Streszczenie

Title: Sensor data acquisition for scientific grade cameras

Abstract

In this master thesis an FPGA implementation of sensor data acquisition for scientific grade camera is presented. Novel X-band silicon sensors have a unique high throughput interface for data and control which needs to be controlled deterministically. The design, implementation and testing of digital system along with firmware pose a great engineering challenge which was analysed and solved in this thesis.

In the first chapter the basics of digital cameras, scientific grade cameras and X-band scientific cameras are presented. Then, then in the second chapter a genesis of the master thesis problem is shown as well as goals and limitations. In the third chapter, requirements for the sensor data acquisition are shown. 4th chapter presents concept of design where digital system and firmware design is specified. In the 5th chapter the realisation and tests of the sensor data acquisition is presented. Final chapter shows the summary of the thesis.

Contents

Chapter 1

Introduction

1.1   Camera systems

1.2   Scientific camera systems

1.3   X-band scientific grade cameras

1.3.1   Scintillation cameras

1.3.2   Silicon sensor cameras

Chapter 2

Genesis

Photonics and Web Engineering Group at the Institute of Electronics Systems had an immensely significant contribution to X-ray based measurement scientific research throughout many years (references). Having a scientific cooperation with another Polish university, there was a need to develop hardware and firmware for novel extremely high-speed, multichannel, X-ray silicon based camera. My work in this project was to develop firmware and to design digital system. This project is undergoing a patent application, and for this reason the detailed description of the project cannot be included in this thesis.

2.1   X-band silicon sensor description

Description

2.2   Thesis problem

The main thesis problem is the X-band counting silicon sensor data acquisition. This problem is not solvable by existing solutions and a custom one has to be designed. The main aspects of the X-band counting silicon sensor acquisition are:

- high throughput interface 8x differential lines with maximum throughput of 5 Gbps per line

- independent of data deterministic control of the sensor with a configuration shift register

Another aspect of the thesis are the system level requirements, such as: multi-channel operation and high speed interface for sensor data transfer.

2.3   Solution

The solution of the thesis problem is to design the readout from the sensor in FPGA fabric along with firmware to facilitate other requirements.

2.4   Goals

To provide a method for acquiring the data from the X-band counting silicon sensor.

2.5   Limitations

This project does not consist of hardware, mechanical or optics design.

Chapter 3

Requirements

1. high throughput multiple serial data acuqisition - 16 differential pairs with up to 5 Gbps per line

2. online and offline sensor data transfer and buffering

3. multichannel operation, possiblity to trigger multiple cameras with high precision (1 ns)

Chapter 4

Concept

4.1 X-band silicon sensor serial data acquisition

4.2 Sensor control

4.3 Firmware

4.4 Communication interfaces

Chapter 5

Realisation

5.1 Sensor data deserialistaion

5.2 Sensor data buffering

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5.4 Synchronisation

5.5 Firmware

5.6 Tests

Chapter 6

Summary

Bibliography

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Appendix A

CD-ROM

- Firmware project files
  - Camera framework project for CMV4000
  - Camera framework project for counting sensor
- piotr_zdunek_thesis.pdf - Master Thesis in PDF format