Camera design framework for scientific applications

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Agenda

- Project genesis
- Requirements
- Concept of design
- Realisation
- Tests
- Future work


π of the sky - camera system

Figure: Example of a scientific camera system

Project genesis

The goal: provide a faster and easier way to develop camera systems for scientific applications
General problems when developing camera systems:

- design of electronics for specific MCU
- development of software/firmware/digital system design to support a specific sensor
- development of data transfer from the sensor to a PC or a storage device
- upgrade capability

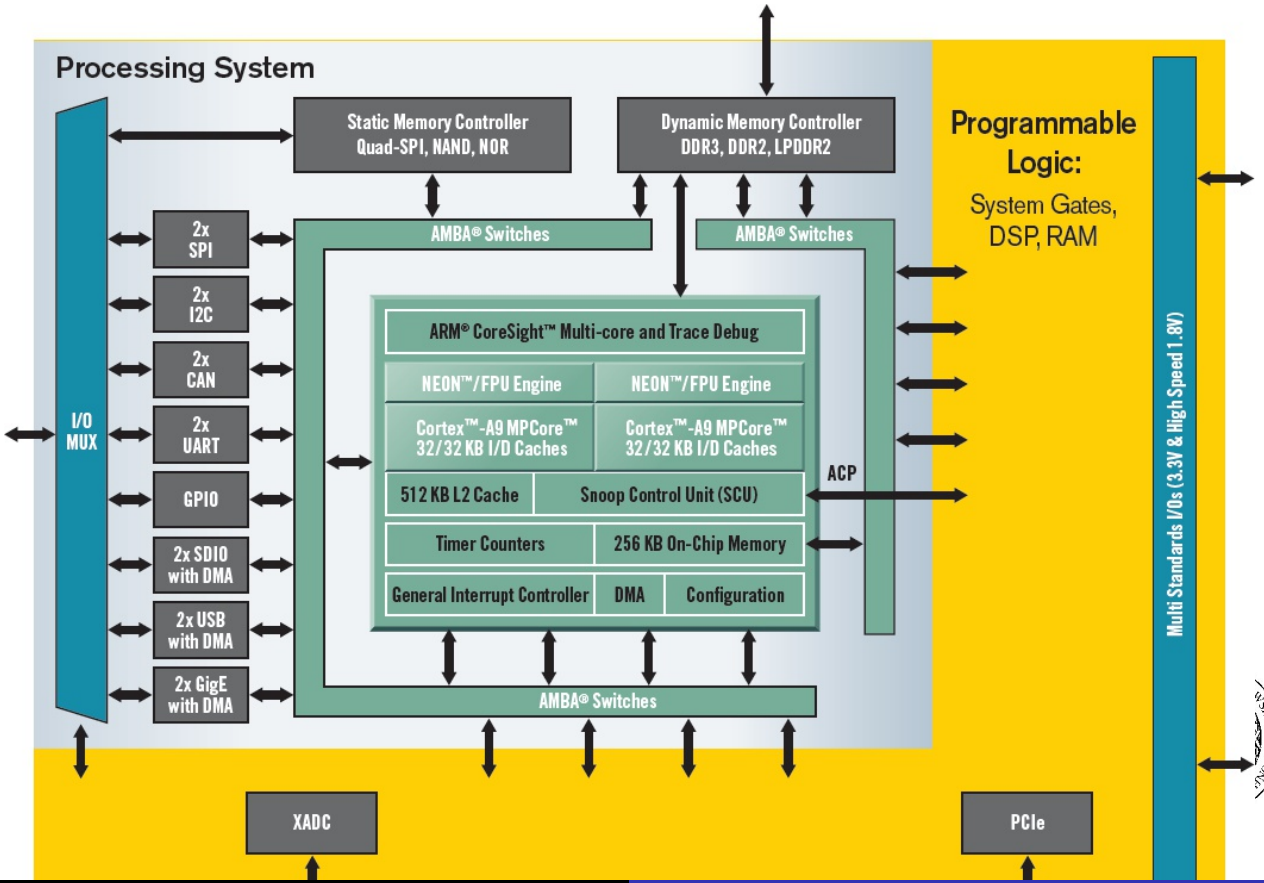

Requirements

1. **High data acquisition** - input throughput 600 MB/s (4 MP @ 100 fps, 12 bits per pixel)
2. **Ease of adding a support for a different sensor**
3. **High speed communication**
   1. 3 Gbps Serial ATA
   2. 1 Gbps Ethernet
4. **Multichannel operation** - Ethernet Precision Time Protocol
5. **Versatile OS**
   1. GNU/Linux
   2. FreeRTOS


Concept of realisation - Main Processing Unit

Xilinx Zynq SoC

- high processing capability - 2x Cortex A9
- high speed connectivity - GTX transceivers - up to 12.5 Gbps per link
- versatility - FPGA fabric
- cost optimal - many variants
- future proof - modern solution



Concept of realisation

Data Interfaces:

- Serial ATA - using an IP Core from OpenCores.org
- 1 Gb Ethernet - using PCS/PMA IP Core (no need to use PHY chip)

Sensors:

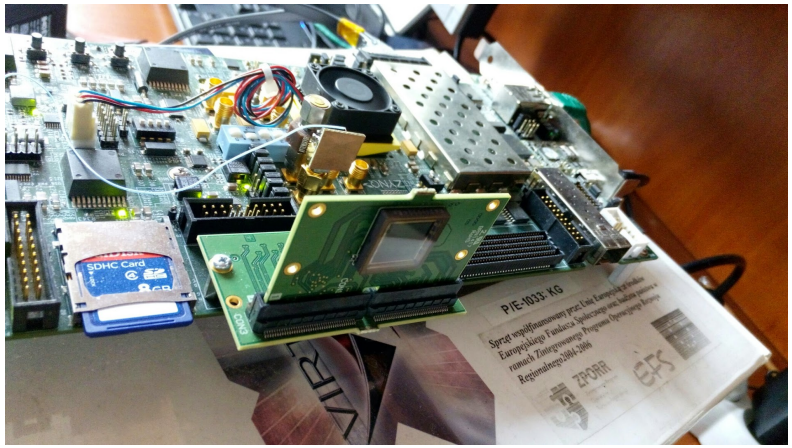
- CMOSIS CMV4000 2 MPix CMOS Sensor - up 100 fps
- Counting detector sensor


Realisation

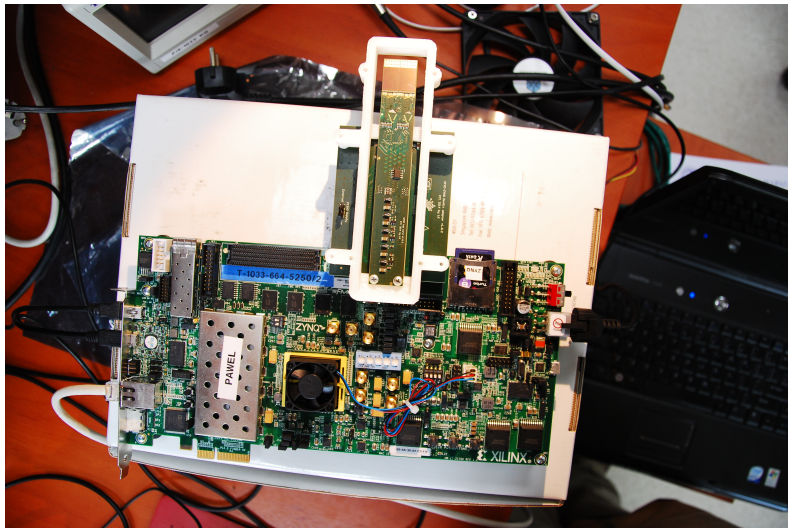
Several subsystems were designed and tested for the project:

- CMV4000 IP data acquisition for ZC706
- Dual SSD Serial ATA data storage
- FreeRTOS/AMP on ZC706
- Counting Sensor IP data acquisition
- Petalinux desgin
- PCS/PMA 1 GbE data transfer

Realisation

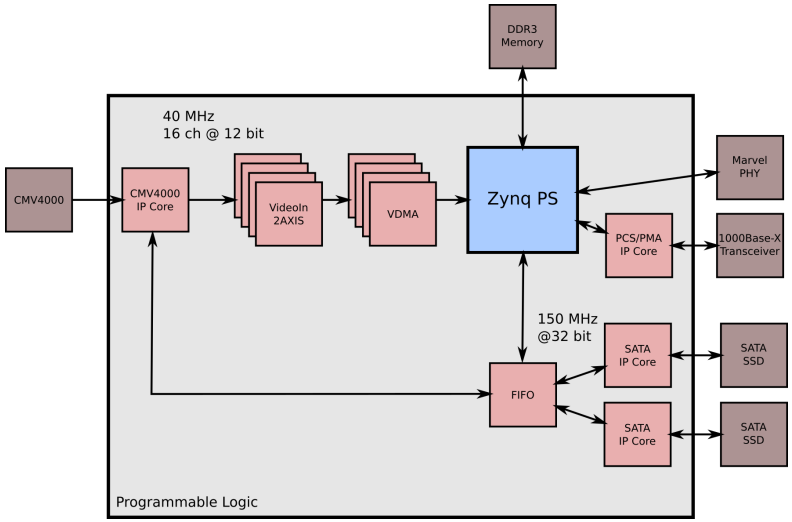


CMOS sensor system

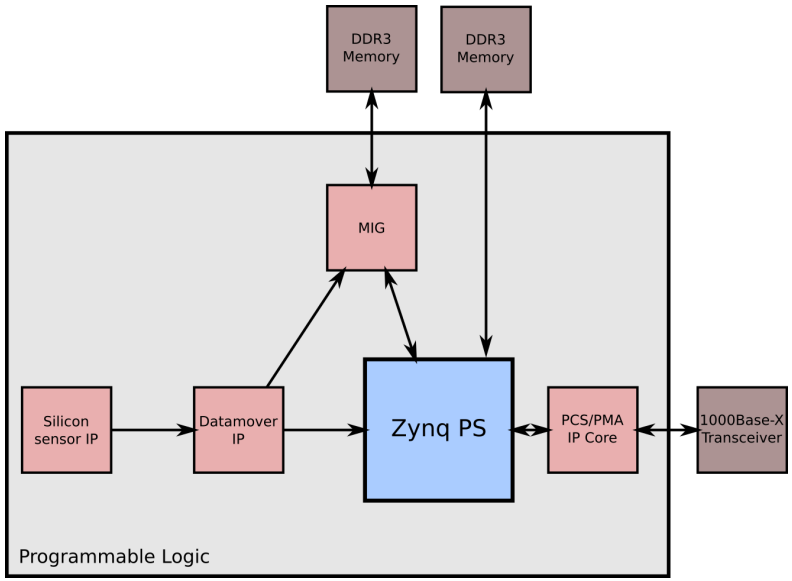


Counting sensor system

Realisation

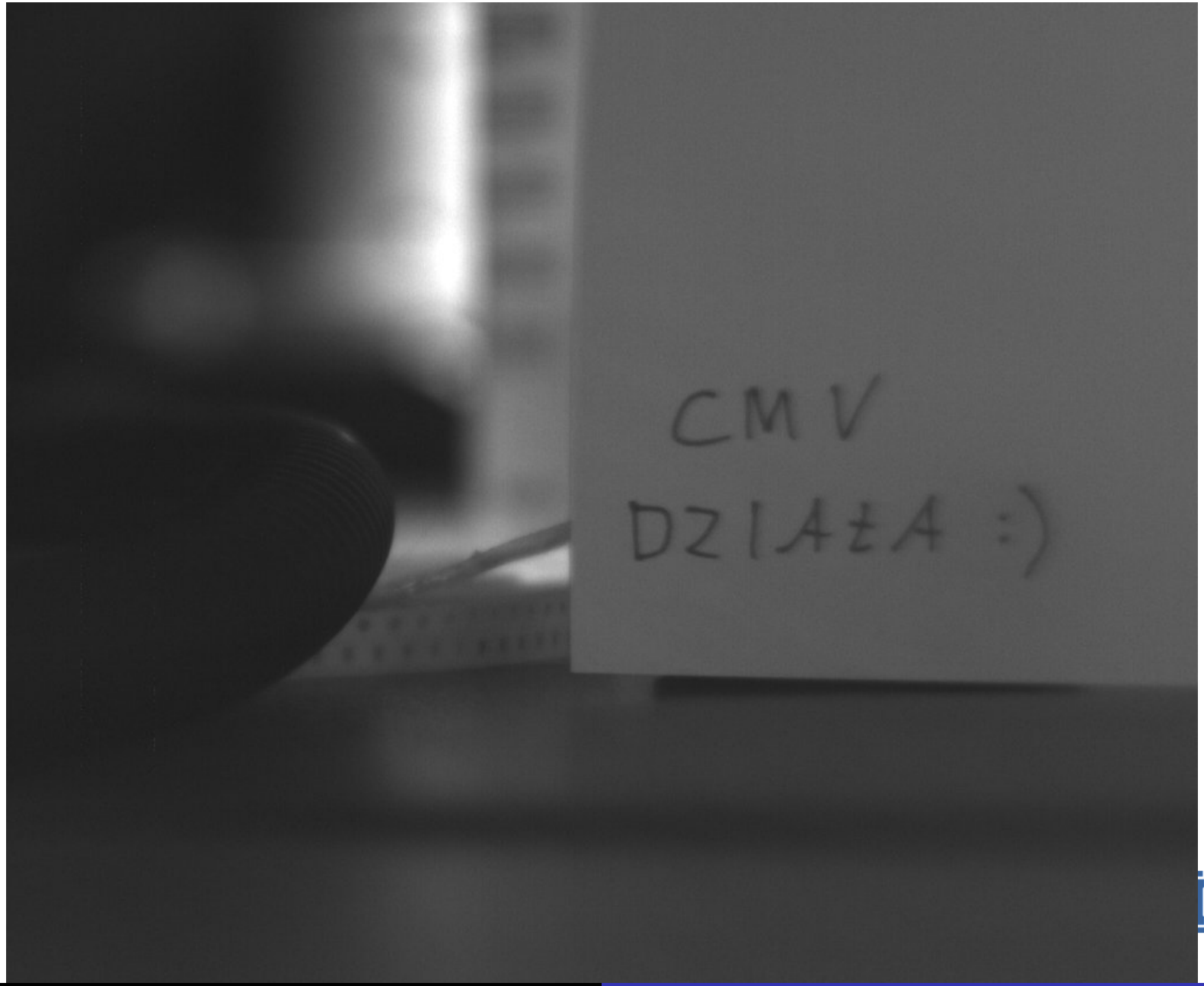


CMOS arch.



Counting arch.

Realisation - CMV4000



Realisation - Counting sensor

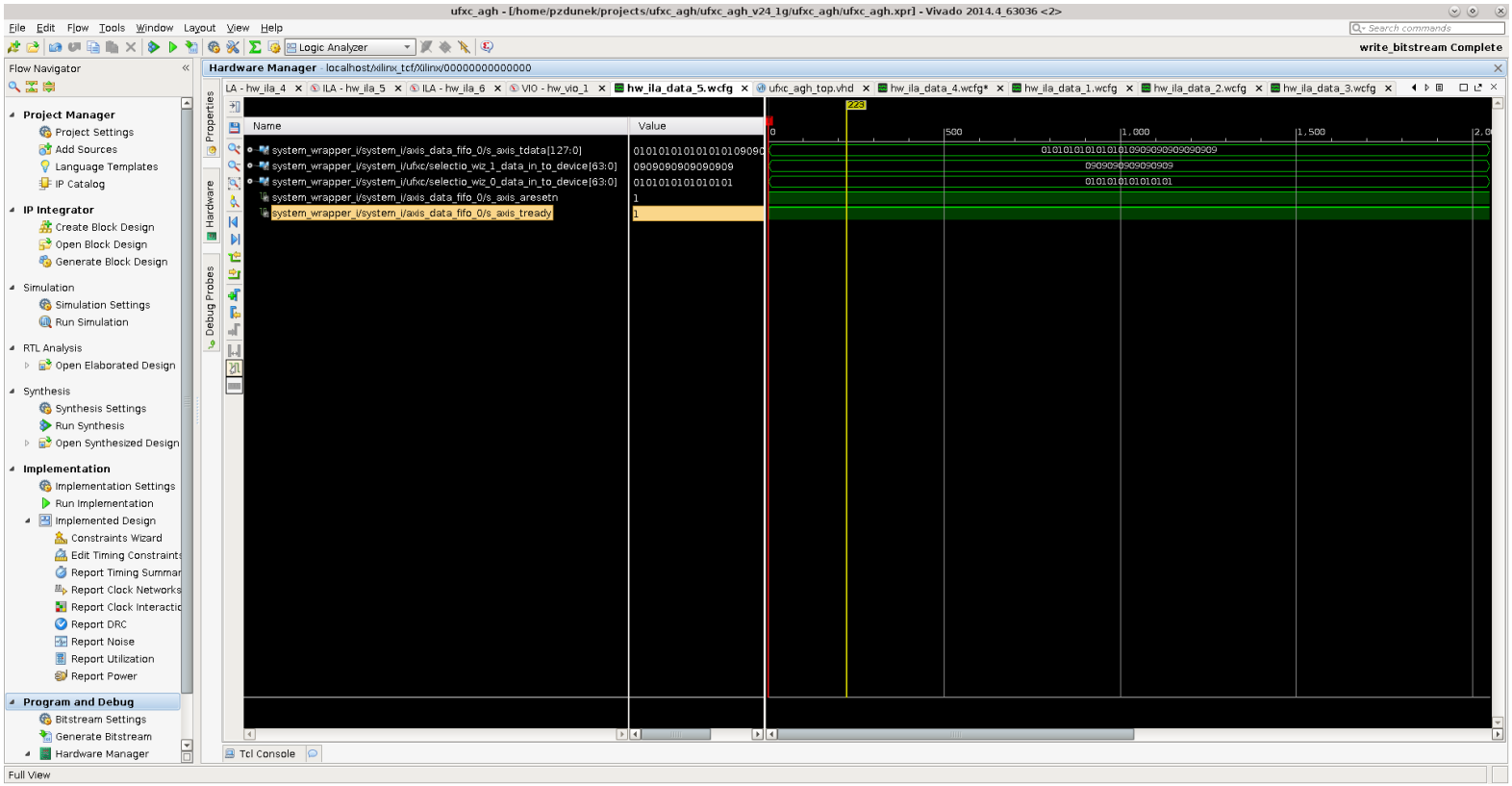


Figure: Readout from the sensor in the loopback mode

Summary

- **Created framework can speed up development of scientific camera systems**
- **Modern SoC are a viable solution for embedded camera systems**
- **The FPGA fabric allows for using different types of sensors with the same hardware**

Possible future upgrades:

- 10 Gbps Ethernet
- MLVDS bus synchronisation for IP Cores controlling the sensor - short range
- White Rabbit synchronisation - for subnanosecond (up to 10 km) synchronisation

Summary

Thank you for your attention!