Standardized Test System for Optical Links in Radiation Environment based on FPGA

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Outline

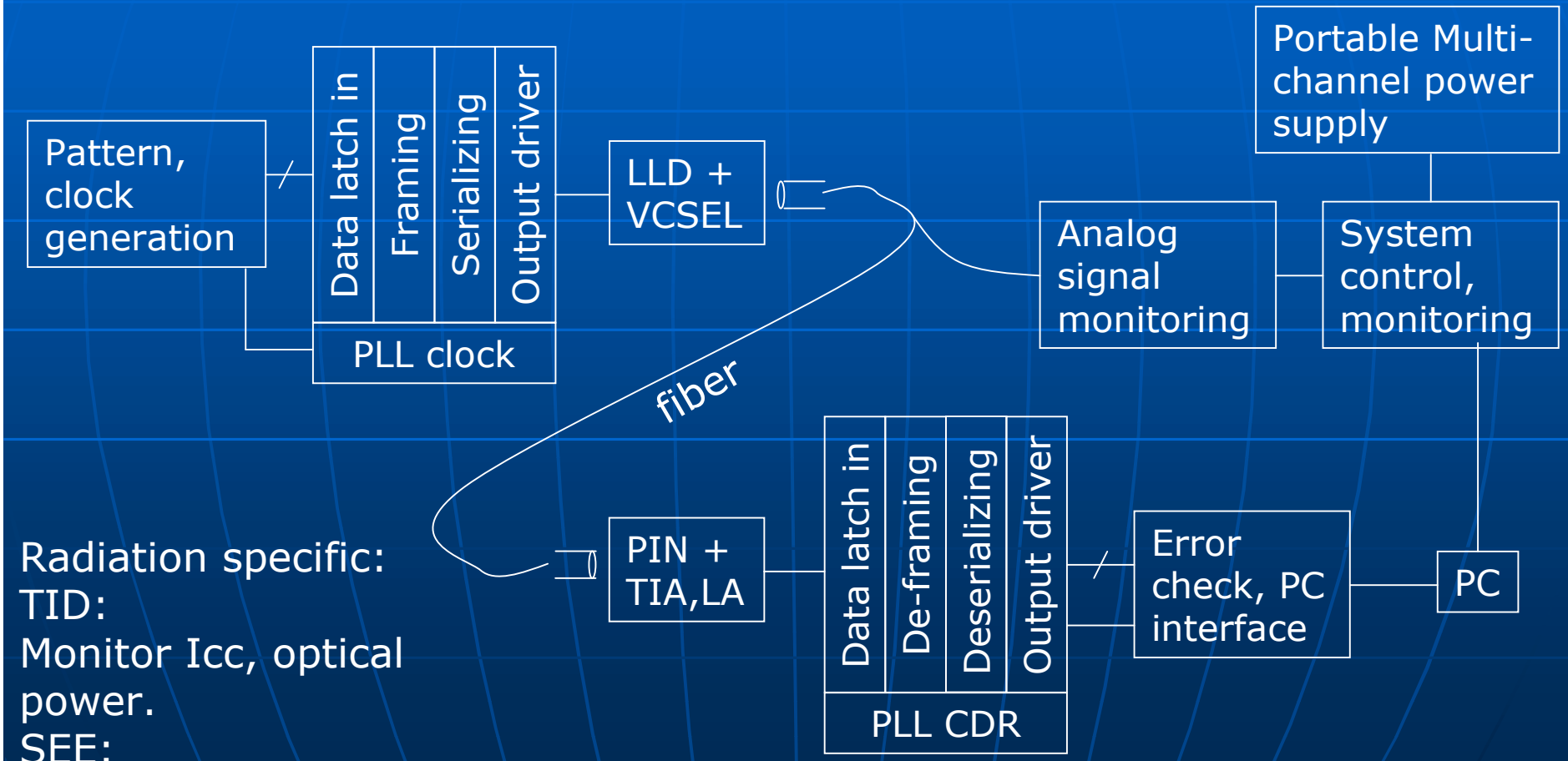
- Issues in irradiation tests on optical links in our R&D work for the ATLAS experiment.
- Standardizing the tests.
- The FPGA based hardware.
- The firmware.
- Applications in our R&D projects and summary.

Issues in irradiation tests on optical links in our R&D work for the ATLAS experiment.

- Optical links for the ATLAS (atlas.ch) experiment:
  - We developed a radiation tolerant 1.6 Gbps, the G-link chipset based optical data link for the ATLAS Liquid Argon Calorimeter front-end electronics readout. This system has a total data rate of 2.5 Tbps, transmitting data from radiation (360 krad) and inaccessible environment. System installed and commissioned.
  - We have two R&D projects for the ATLAS upgrade:
    - Ultra low power, radiation tolerant optical data link based the GOL ASIC (CERN, cern.ch), operates at 800 Mbps and 1.6 Gbps.
    - Ultra low power, radiation tolerant optical data link employing the link-on-chip concept, ASIC based on Silicon on Sapphire technology (SMU), operates at 3.2 Gbps.

Issues in irradiation tests on optical links in our R&D work for the ATLAS experiment.

- Tests on optical link for serial data transmission:



Radiation specific:
TID:
Monitor Icc, optical power.
SEE:
SEU, SEL, frame loss, etc.

Issues in irradiation tests on optical links in our R&D work for the ATLAS experiment.

- Functional tests:
  - Center for optical link development for applications in radiation and harsh environment at SMU.
  - We follow IEEE standards.
- Irradiation tests:
  - Total ionizing dose (TID) effect.
    - We monitor the supply currents to each device under tests as functions of dose rate and total dose.

      ➔ Portable multi-channel power supply with current measurements (we developed).
    - We monitor optical power.

      ➔ Multi-channel optical power meter (we developed).
  - Single event effect (SEE).
    - We monitor SEL.
    - We monitor SEU: single-bit flip, multi-bit flip, frame-loss errors.

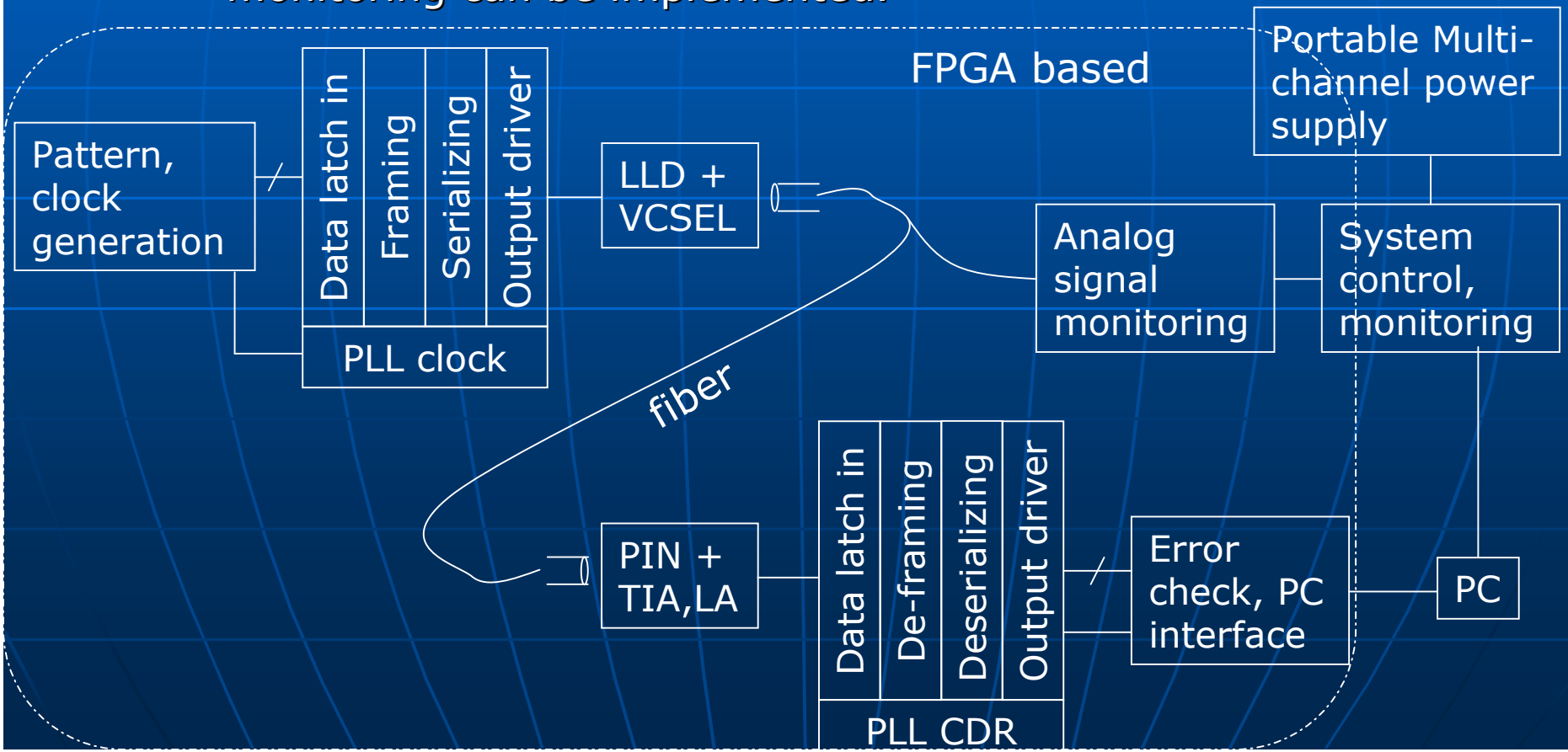
      ➔ portable parallel BERT with data logging capability (we developed).

Standardizing the tests

- Difficulties in R&D for systems in radiation environment:
  - Very few parts on the market are specified to be rad-tolerant.
- Custom developments (ASIC, subassemblies) and testing (tools and test procedures) are needed.
- Often the testing requires a complete system even when you only develop one part for that system.
- More effective and economical to standardize the test procedures and evaluation criteria: we generated such a document in ATLAS in collaboration with CMS (the two experiments at the LHC). This document can be made available upon request.

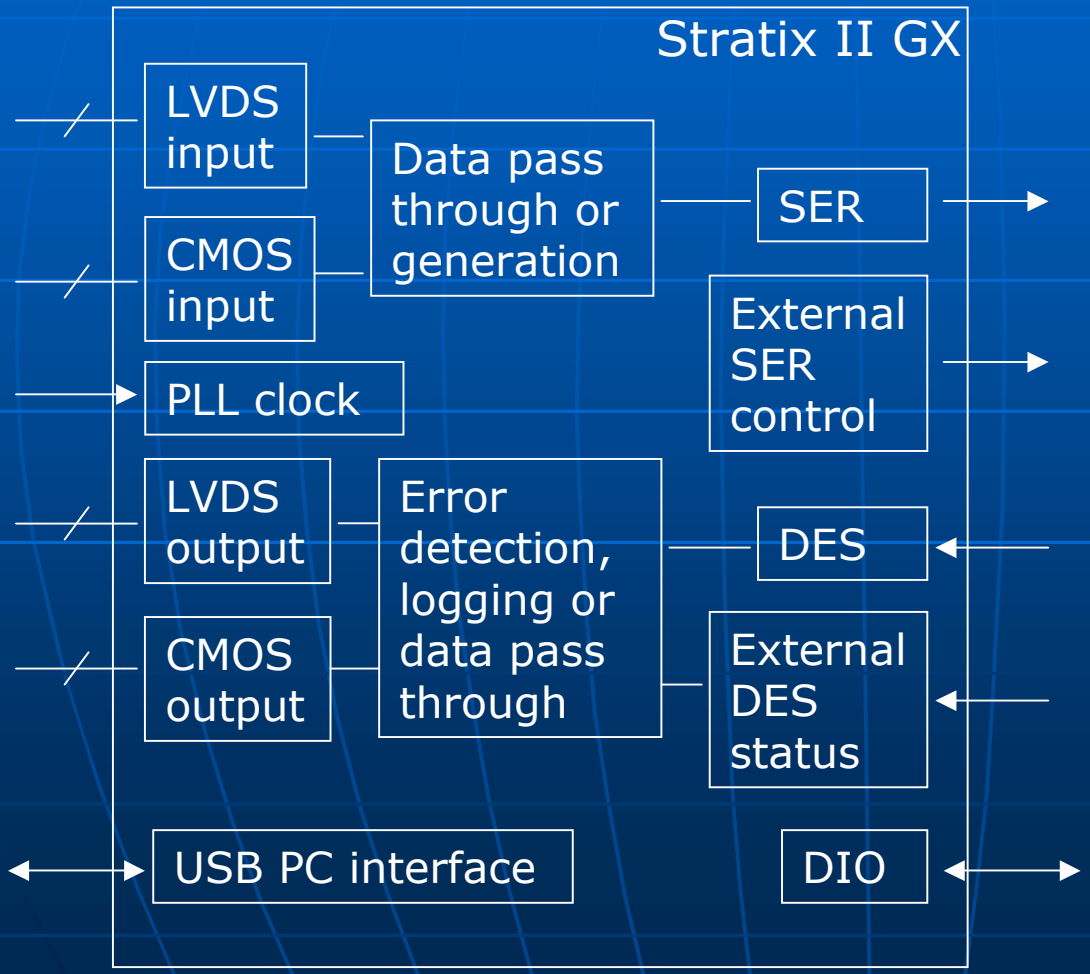
The FPGA based hardware

- Stratix II GX is chosen to be the center of the hardware.
  - 6 channel 600 Mbps to 6 Gbps serdes.
  - PC interface (USB).
  - Can be configured to a complete link, or (almost) any part in the testing setup of the link. With PIN+ADC, analog signal monitoring can be implemented.



The firmware

- The core part of the firmware is the pattern generation and error checking and processing:



Error detection and logging:

1. Type I: single bit flip.
2. Type II: multi bit flips in one frame.
3. Type III: frame loss, or errors in consecutive frames.
4. All errors are recorded with a time stamp from the reference clock.

This ensures full information for offline data analysis.

Applications in our R&D projects and summary

- High speed serial data is the future of data transmission links.
- We are developing radiation tolerant, low power optical data link in multi-gigabit per second range. One system is based in the GOL ASIC (CERN, DSM technology), the second system is based on the 0.25 micron silicon on sapphire CMOS technology (SMU). We have evaluated this SOS technology to be radiation tolerant. (See our presentation in RADECS 2007).
- The FPGA based test setup we developed will be widely used in the experimental high energy physics community, and will make our R&D programs more effective and cost efficient.

Thank you!