Gotthard: a charge integrating silicon strip detector for XFEL and Synchrotron applications.

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Automatic gain principle

Before the measurement the amplifier is in reset and the gain is set to high. When the reset is released the charge starts to be integrated on the feedback capacitor.

If the output of the amplifier reaches the threshold, a 2nd or 3rd stage is switched in, thus lowering the output.

At the end of the measurement the analog gain information may be readout.

The switching works for an instantaneous charge release (e.g. XFEL pulse) as well.

The detector module

The detector module consists of 10 readout ASICs for a total of 1280 channels at 50 µm pitch. Each module is an independent unit with its own Gigabit link, for fast frame rates (60 kHz continuous, 1 MHz in bursts) and easy scalability. Slow control is handled by a Blackfin embedded Linux system.

Test results

GOTTHARD systems have been tested with X-Ray fluorescence light and at Synchrotron sources.

- Noise ~200 e.n.c. (r.m.s.) for High Gain mode
- Noise ~300 e.n.c. for the 1st gain of gain switching mode
- Nois for low gains ~10 times smaller than Poisson fluctuations
- Saturation at 10^4 photons
- Gain variation better than 1.5%
- Linearity within 0.5%

GOTTHARD specifications

- ASIC technology: IBM 130nm technology
- Module size: 6.7x12.5cm
- Sensor area: 64.8x19mm
- Sensor thickness: 320-500 µm
- Pitch: 50 µm
- Noise r.m.s.: ~300 e.n.c.
- Dynamic range: 10^4; 12keV photons
- Minimal Energy: <4 keV
- Linearly: better than 0.5%
- Spill spread function: ~1% (pitch)
- Rise time: 50ns
- Fall time: ~50ns
- Cooling: air
- Readout rate: 5 MHz continuous; 1 MHz burst

Applications

XFELs:
- powder diffraction
- XES/XAS (with energy dispersive optics)
- diagnostics
  - Synchrotron: discovery experiments, high photon rates
  - pump and probe experiments in 10kHz-1 MHz rep. rate range
  - profile monitors, diagnostics

Synchrotron: FPGA data processing
- board architecture and data flow
- operation modes for Synchrotron applications

Board architecture and data flow

At 1 MHz frame rate the data transfer to the file server is not possible. Depending on the application, two solutions are available.

- EU-XFEL or fast pump probe experiment: burst mode with local storage ~350 frames on the FPGA
- Synchrotron: FPGA data processing

Operation modes for Synchrotron applications

- Position interpolation
- Window discrimination
- Per channel energy binning
- Zero suppression