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Status and Prospects of Readout and Control Systems for Real-Time X-ray Beam Monitoring at SenSiC GmbH

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SenSiC GmbH is a Swiss technology company delivering advanced Silicon Carbide (SiC)–based sensor solutions and customized electronics for high-brilliance X-ray and particle beam diagnostics. Originating as a spin-out of the R&D activities of the Swiss Light Source (PSI), SenSiC designs and manufactures ultra-compact, radiation-hard beam position (XBPM) and intensity monitors tailored for high-brilliance X-ray beams in synchrotron and accelerator facilities.
Besides the SiC sensors, which will be presented by Dr. Trovato in this workshop, a central element of the detection platform is the PCR4, a multichannel pico-to-milliammeter system designed for the readout of SiC X-ray Beam Position Monitors (XBPMs). The system performs bipolar current measurements across a very wide dynamic range, from ±2.5 nA up to ±50 mA, with nominal resolution down to a few femtoamperes, noise levels down to 1 ppm (@10 Hz) with respect to the selected current range, and sampling frequencies up to 10 kHz at 24-bit resolution. It integrates a programmable sensor bias source (±20 V) and communicates through standard Ethernet interfaces compatible with both EPICS- and TANGO-based control infrastructures. This architecture enables accurate current measurements across more than five decades, supporting precise beam diagnostics and high-resolution spatial monitoring of synchrotron radiation beams, the system has been tested in multiple beamlines at PSI/SLS. The PCR4 also incorporates a proportional–integral feedback control system for active beam stabilization. The system has been experimentally validated at the SOLEIL synchrotron (GALAXIES beamline), where slow drifts during energy-scan experiments were effectively compensated, reducing the RMS beam displacement from approximately 15 µm to about 1 µm at the feedback monitor.
Together with this system, the company is now working on three important developments: (i) dual-sensor monitoring, (ii) multi-sensor asynchronous readout, and (iii) Enhanced Lateral Resolution (ELR) Front-Ends (FE).
(i) By using a multi-input multi-output (MIMO) controller based on signals from two synchronized XBPMs, it will be possible to reconstruct, and correct in real time, both beam tilts and beam offsets thus compensating the angular and translational components of beam motion and enabling stabilization directly at the sample location. First experimental tests on this new system are planned for May at the SOLEIL synchrotron.
(ii) Multi-sensor asynchronous readout (MUX) enables the connection of up to 16 signal channels and 4 bias lines, corresponding to the monitoring of up to four XBPMs. This architecture allows several beam position monitors, each optimized for a specific photon-energy range, to be operated and read out using a single acquisition system without the need for parallel hardware. The MUX system is fully integrated with EPICS and TANGO control frameworks, the system has been tested at BESSYII synchrotron facility.
(iii) ELR-FE circuits are dynamically adjustable transimpedance stages capable of optimizing the mapping between sensor signal and the ADC input range. They allow maximizing sensitivity thus enabling significant improvements in beam position lateral resolution. Preliminary results indicate resolution enhancements exceeding a factor of five, benefiting all sensor types but particularly improving the performances of resistive-XBPM and White-beam sensors.
These results demonstrate the effectiveness of the PCR4 platform for high-dynamic-range beam diagnostics and active beam stabilization, while ongoing developments aim to further extend the capabilities of SiC-based instrumentation to meet the increasingly stringent requirements of real-time beam monitoring in modern high-brilliance synchrotron beamlines

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