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Digital processing and BLMASIC control prototype for the Beam Loss Monitor system in the SPS at CERN.

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The Beam Loss Monitoring system plays a crucial role in the CERN's Super Proton Synchrotron beam monitoring and machine protection. With the upcoming renovation of the system, the acquisition electronics can be based on an innovative ASIC designed by CERN. This paper presents the development of the control and digital processing electronics for this BLMASIC, reviews the architecture and design choices, discusses implementation details, including the controls and redundancy schemes, and highlights some preliminary results. The conclusion outlines the future development steps, and emphasises the interest of this simple and robust architecture using LpGBT and VTRx for critical systems.

Summary (500 words)

Introduction:
This study presents the development of a prototype for the control and digital processing electronics of the BLMASIC for the renovation of the Beam Loss Monitoring (BLM) system of the Super Proton Synchrotron (SPS) during the LHC Long Shutdown 3 (LS3) at CERN.
Background:
The current BLM system has already had several decades of successful operation in beam monitoring and machine protection. As spare components are becoming rare and obsolete, a complete renovation is planned during LHC Long Shutdown 3 (LS3). The new specification of the system meets both the SPS and LHC needs, as the same hardware will be deployed at the LHC during LS4. Enhanced capabilities of this newly designed system will include 1 kGy radiation tolerant electronics, 8-order dynamic range, 10 µs acquisition period and flexible real-time digital processing.
BLMASIC overview:
The core of the new acquisition electronics of the future BLM SPS system can be the BLMASIC. This current measurement ASIC, developed by CERN, is the result of a choice between two versions: ADC delta-sigma and current-frequency conversion. The characterisation of the two topologies is described, and the radiation tests of the selected version are detailed.
Remote control:
The BLMASIC control and processing electronics are based on the standard VFC-HD platform of CERN's Beam Instrumentation (BI). This backend VME platform uses remote configuration capabilities via optical links and local I2C links to control the acquisition electronics placed in the tunnel. The remote control of the 4 BLMASICs via 2 LpGBTs and 2 VTRxs is explained. Redundancy in the system is also discussed, including the selection of the active link and the recovery sequence in case of link failure.
Digital processing:
The digital electronics architecture and FPGA-based implementation used in the prototype, including the implementation of running sums, raw data buffers and threshold comparison, are discussed in this section. Several improvements are also proposed for the development of the final operational system.
Prototype testing:
The prototype BLMASIC digital processing and control electronics was tested in the laboratory with a current

source and installed in the SPS in 2023. Some preliminary results are presented in this section. Measurements with beam should provide valuable data for further analysis.
Future implementation:
This section presents the complete picture of the new system, including the detectors, the acquisition and processing box, and the software and databases. The benefits of using BLMASIC are highlighted, including reduced component count, increased radiation tolerance, additional redundancy and diagnostics. Integration with other SPS control systems, such as timing configuration, fieldbus network communication, is also discussed, as well as the potential for reuse of the hardware in the LHC during LS4.
Conclusion:
The development of a control and processing electronics prototype for BLMASIC was presented. The results of the study are summarised and future development steps, including further testing, integration and potential reuse, are described. The implications of this development for engineers involved in the use of LpGBT and VTRx are highlighted, providing an example of a simple and robust control system architecture for critical systems.

Author: SACCANI, Mathieu (CERN)

Co-authors: ZAMANTZAS, Christos (CERN); EFFINGER, Ewald (CERN)

Presenter: SACCANI, Mathieu (CERN)

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