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Design of Differential Beam Current Measurement System for Fast Protection in CSNS-II Linac Upgrade

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The upgrade of linac in China Spallation Neutron Source (CSNS-II) requires a robust Differential Beam Current Measurement (DBCM) system to ensure safe operation of superconducting cavities within the Fast Protection System (FPS). This paper presents a practical design for a DBCM system tailored for the chopped-beam operation. The system integrates a Bergoz Fast Current Transformer (FCT) with a 0.5 V/A sensitivity, front-end analog electronics featuring fast-switching OPA680 amplifiers, and a Xilinx Zynq UltraScale+ RFSoc-based FPGA digital board for real-time signal processing. Key features include band-pass filtering, digital droop compensation using an IIR filter to achieve $< 0.5\%$ pulse height accuracy, and DC restoration for precise baseline correction. The RFSoc platform supports high-speed ADC sampling (≥ 500 MSa/s), trigger logic for < 200 ns interlock response, and data storage for 10 macro-pulses (~ 6.5 ms). Integrated into a Linux-based EPICS environment, the system ensures reliable, high-precision beam monitoring, meeting CSNS-II's stringent requirements for superconducting cavity protection.

Footnotes

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