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Control of Transverse Intra-Bunch Instabilities using GHz Bandwidth Feedback Techniques.

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Electron cloud driven instability can impose limitations on the maximum stored beam current in present and future accelerators. It drives inter-bunch and intra-bunch instabilities. Feedback control techniques have been proposed to mitigate transverse instabilities within a bunch as an extension of techniques used to control inter-bunch (coupled-bunch) instabilities.

The US LHC Accelerator Research Program (LARP) has supported a collaboration between US labs and CERN to explore systems to mitigate E-cloud instabilities and transverse mode coupled instability (TMCI) for the SPS and LHC machines. For intra-bunch (within a bunch) control of nanosecond scale bunch lengths the feedback channel has to be wide-band (GHz range) to be able to measure and control the vertical position of individual sections of a bunch.

The design and implementation of the feedback control system involves the modeling and identification of the bunch dynamics, the design of a feedback control algorithm, and the selection of digital and analog hardware that operates in the GHz range. We present the goals of this collaboration and analyze the different research lines to implement and evaluate a full-function prototype feedback system for the SPS. We include details of the feedback system topology and technical limitations, modeling and identification of the bunch dynamics via simulators and machine measurements. We estimate the necessary control bandwidths, and complexity of the processing channel via design considerations for the control algorithm. Very initial efforts at modeling feedback control via reduced bunch models and semi-realistic feedback system specifications are presented.

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