Contribution ID: **2166** Contribution code: **THPA092** Type: **Poster Presentation**

The CERN SPS Low Level RF feedback with amplitude and frequency modulation

Thursday, 11 May 2023 16:30 (2 hours)

The CERN SPS Low Level RF (LLRF) has undergone a major upgrade, including the complete redesign of the 200 MHz Cavity-Controllers [1,2] and the Beam-Control [3]
during the Long Shutdown two (LS2) in 2018-21. Two major goals motivated the upgrade, first the required doubling of the proton beam intensity injected from the Super Proton Synchrotron (SPS) for the High Luminosity Large Hadron
Collider (HL-LHC) project, second the implementation of the slip-stacking of two families of ions bunches, 100 ns spacing, to generate a 50 ns spacing after interleaving. This paper presents new features of the 200 MHz Cavity-Controller part,
that is responsible for the regulation of the accelerating field in a single SPS cavity. Unlike the pre-LS2 implementation, the new system supports 100% Amplitude modulation (AM) and Frequency Modulation (FM) for the One-Turn delay FeedBack (OTFB) and for the Feed-ForWarD (FFWD).
The AM was commissioned and used with physics proton and lead ions beams during the SPS 2022 run. The new elements required for the modulations are reviewed
and details are provided on the implementation: delay and phase compensations to synchronize the cavity voltage measurement for the cavity field regulation with the AM and FM, synchronization of multiple cavities, and the velocity compensation for the heavy Ion acceleration. Finally, results of the cavity field regulation with amplitude modulation in 2022 are presented.

Funding Agency

Footnotes

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Yes

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Session Classification: Thursday Poster Session

Track Classification: MC6: Beam Instrumentation, Controls, Feedback and Operational Aspects: MC6.T27: Low Level RF