Tuning rules for the digital filters of the SIS 100 longitudinal feedback system

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Damping of longitudinal coherent bunched-beam oscillations is needed in SIS100 to stabilize the beam, prevent emittance growth and keep beam loss low during acceleration. An FIR (finite impulse response) filter approach with 3 taps, cf. [1], which has already been successfully used at GSI in several machine experiments for beam-phase control in a longitudinal feedback system has further been investigated. The dissertations [2] and [3] deal with an analytical way of how to apply the tuning rules for this approach for stationary, single and dualharmonic operation. In last year's work, extensive tracking simulations were performed to investigate the performance of the feedback system in terms of emittance-growth and settling-time numerically regarding the two tunable parameters of the FIR-filter.

Feedback system

The feedback system can be separated into two parts. One is a bandpass filter, implemented as a symmetric, biasfree bandpass filter. The bandpass frequency, which scales with the linear synchrotron frequency can be detuned by the frequency modificator χ, which is one of the tunable parameters.

The bandpass filtered bunch-phase is integrated and multiplied with a gain factor, to obtain a phase-shift in the gap voltage. The gain-factor also scales with the linear synchrotron frequency. It can further be modified by the gain factor modificator k.

Simulation settings

The tracking simulations have been performed to get a tuning rule for the feedback system, especially for the case of different bunch lengths, synchrotron frequencies and particle energies. Therefore typical synchrotron frequencies for SIS18 (below 2 kHz) and SIS100 (below 1.5 kHz), as well as bunch lengths reaching from 115° to 200° have been tested. The bunch length is the smallest phase range within a bucket, which contains 85% of its particles.

For testing the performance of the filter, the phase of the gap voltage was shifted by 10° to induce a longitudinal dipole oscillation.

Results

In stationary operation constant tuning rules are sufficient. For single harmonic operation the frequency modification factor χ is between 0.95 and 1.0, the gain factor modificator at 0.25. This is comparable to the results for linear buckets in [2].

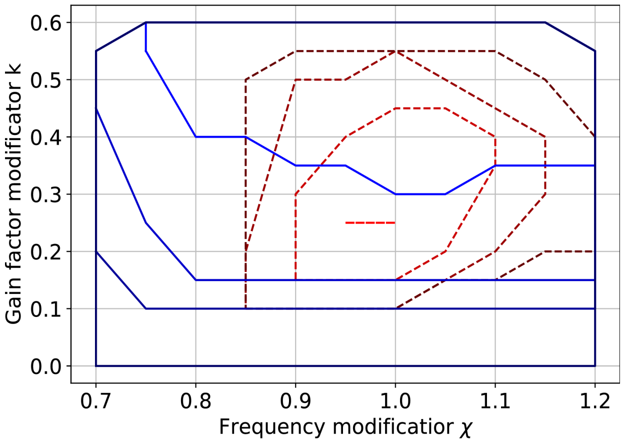

Figure 1: Parameter scan for single-harmonic operation with a bunch-length of 115°. In dashed red are the areas for 2, 3, 4 and 5 oscillations (light to dark) settling time. In solid blue are the areas for 10%, 30%, 50% and 100% (light to dark) relative emittance-growth compared to system without feedback.

For dual-harmonic operation the frequency modification factor is at 0.8 and the gain factor between 0.2 and 0.25. For both parameters, this is about 80% of the parameters used in machine experiments in [3].

In both cases the system is tuned to fast settling times. Notable RMS-emittance-growth from longitudinal dipole oscillations only occurs when the amplitude reaches more than 3 degrees. High damping rates should prevent such critical states.

Outlook

As constant tuning rules for single- and dual-harmonic stationary operation for a large variety of longitudinal beam parameters are sufficient to obtain strong damping rates and decreased RMS-emittance-growth from longitudinal dipole oscillations, it has to be studied whether this also holds on acceleration ramps, due to the strong deformations of the separatrix.

References

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