Progress in damping of longitudinal beam oscillations during acceleration*

D. Lens†1, *U. Hartel*[1], *H. Klingbeil*[1,2], *B. Zipfel*[1], *K. Groß*[2], *J. Adamy*[3], *B. Reichardt*[3], *M. Kumm*[4], *K. Möller*[4], *and P. Zipf*[4]

[1]GSI; [2]TU Darmstadt, TEMF; [3]TU Darmstadt, RMR; [4]University of Kassel, Digital Technology Group

Introduction

In the FAIR synchrotrons, coherent longitudinal oscillations of the bunched beam will have to be damped by dedicated feedback systems. While the damping for coasting beam energy has been successfully verified in SIS18 by several experiments (cf. e.g. [1]), the damping of these modes during the acceleration process poses additional challenges. The main technological issues are discussed and a progress status is given. For details on the longitudinal feedback system for FAIR with bunch-by-bunch feedback, we refer to [2].

Status of Main Projects

Group-DDS Phase Calibration

For the low-level RF (LLRF) system, it is essential that reference signals are provided with a phase stability better than 1°, cf. [3]. Such reference signals are generated by DDS modules, which show a frequency-dependent behavior during the acceleration ramp that must be compensated to reach the high accuracy requirements. A compensation strategy using calibration electronics has been employed and verified in beam experiments [3]. In addition, a software tool has been developed which enables a semi-automatic calibration, drastically reducing the effort to perform a calibration of a DDS crate.

Feedback Tuning During Acceleration

A finite impulse response (FIR) filter is used for the damping of longitudinal modes. For this filter, a tuning rule based on the synchrotron frequency was already experimentally verified in the past. In a recent beam experiment [4], the successful damping of coherent quadrupole oscillations during acceleration has now been demonstrated, cf. Fig. 1. The results are currently being used to verify the tuning strategy during acceleration.

FPGA Implementation of Tunable Filter

A dynamically reconfigurable FIR filter has been implemented on an FPGA [5] and will be integrated into the existing framework of the DSP system [1] used for longitudinal feedback. The next step will then include the implementation of the tuning rule for the adaption of the filter coefficients.

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† d.e.m.lens@gsi.de

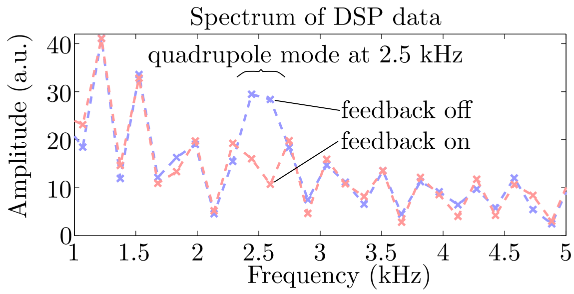

Figure 1: Damping of longitudinal coherent quadrupole modes in SIS18 during acceleration, Sep. 7, 2014.

Optimized Filter Design

The filter implementation [5] in principle allows for more complex filters with a larger number of coefficients than currently used. In a cooperation project with TU Darmstadt (RMR), the potential of these longer filters is currently analyzed. Measurements with beam showed as a proof of principle that the damping of the closed loop may be increased. However, careful investigations are still necessary to study possible implications concerning noise and robustness.

Future Work

The phase response compensation of DDS modules will be automated further to enable periodic calibrations of the reference DDS crate to compensate long-term drifts.

Concerning the damping of longitudinal modes, further steps will be taken towards standard operation as described in [4].

References

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