Beam Phase Feedback for Dual-Harmonic Operation of RF Cavity Systems*

J. Grieser[†1], U. Hartel[1], H. Klingbeil[1,2], U. Laier[2], D. Lens[1], K.-P. Ningel[2], S. Schäfer[2], and B. Zipfel[2]
[1]Technische Universität Darmstadt, Darmstadt, Germany; [2]GSI, Darmstadt, Germany

Introduction

After completion of the FAIR Project, the SIS 18 will be used as pre-accelerator for the SIS 100/300 and its cavities will be run in dual-harmonic bunch lengthening mode (BLM). To damp longitudinal rigid dipole oscillations a phase feedback system is used [2] which was so far only tested for the single harmonic mode. The beam phase signal with respect to the group DDS (Direct Digital Syntheziser) signal driving the cavities is filtered by an FIR (Finite Impulse Respond) filter and fed back to the group DDS. On November 21st 2012 a beam experiment was carried out showing that dipole oscillations can be damped using an FIR filter also in the dual-harmonic mode. Some of the results were already presented in [1, 3].

Control Loop

An overview of the feedback loop is given in Fig. 1. Electrical (analog or digital) signals are indicated by a black arrow and optical signals by a dashed red arrow.

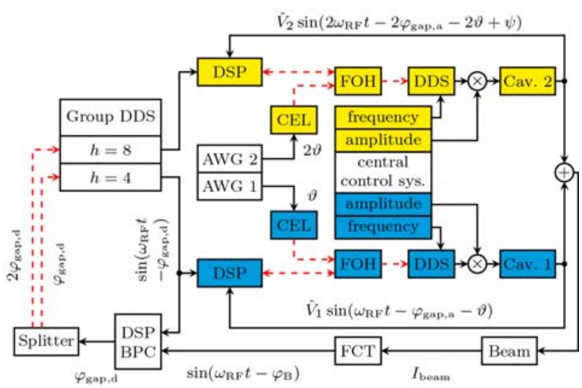

Figure 1: Beam phase feedback loop

To each gap voltage an additional phase shift ϑ (respectively 2ϑ) can be applied by means of an input voltage at the CEL (Calibration Electronics Modules) using an AWG (Arbitrary Waveform Generator). This is used to excite dipole oscillations on flattop while the basic frequency (and amplitude for acceleration) is supplied by the central control system. Both cavities synchronize with a group DDS signal whose phase can be changed by the splitter, doubling the desired phase shift $\varphi_{\mathrm{gap,d}}$ at its input for the second harmonic ($h = 8$) cavity. Beam phase control is realized in the DSP (Digital Signal Processor) denoted as 'DSP BPC'. It consists of a phase detector, a digital filter, an integrator and a gain K as can be seen in Fig. 2. The beam current I_{beam} is measured with an FCT (Fast Current Transformer). The FOH (Fiber Optic Hub) transmits data between DSP, CEL and DDS of each cavity.

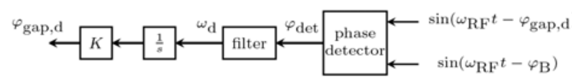

Figure 2: Block diagram of BPC DSP algorithm

The controller feeds back the phase difference $\varphi_{\mathrm{det}} = \varphi_{\mathrm{B}} - \varphi_{\mathrm{gap,d}}$ (with φ_{B}: phase of bunch barycenter and $\varphi_{\mathrm{gap,d}}$: desired cavity phase shift for $h = 4$), filtered by the FIR filter [2]

$$H_F(z) = -\frac{1}{4} + \frac{1}{2} z^{-1/(2T_{\mathrm{s}} f_{\mathrm{pass}})} - \frac{1}{4} z^{-1/T_{\mathrm{s}} f_{\mathrm{pass}}}, \qquad (1)$$

where f_{pass} is the passband center frequency of the filter. The bunches were rigidly displaced by $\varphi_{\mathrm{B}}(t_0) = 20°$ at a flattop energy of $E_{\mathrm{kin}} = 120$ MeV/u, representing a test scenario in which a dipole oscillation with a defined amplitude is excited. Fig. 3 shows a dipole oscillation in closed and open loop. The additional damping is clearly visible.

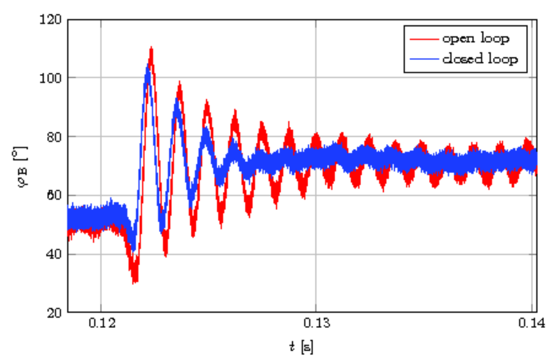

Figure 3: Measurement of dipole oscillation damping

Acknowledgment

The authors would like to thank W. Kaufmann, A. Klaus, H. G. König, D. Mondry, P. Moritz, H. Reeg, S. Reimann, G. Riehl, P. Schütt, P. Spiller, C. Thielmann, T. Winnefeld and others who have contributed to the success of the experiment but could not be listed here.

References

[1] J. Grieser et al., WEPME004, Proceedings of IPAC 2013
[2] H. Klingbeil et al., IEEE Trans. Nucl. Science, Vol. 54, No. 6, 2007
[3] H. Klingbeil and J. Grieser, GSI-Memo No. 07012013, 2013
[4] K.-P. Ningel et al., TUPEA037, Proceedings of IPAC 2010

* Work partly supported by GSI-TU Darmstadt cooperation contract
† jgrieser@rtr.tu-darmstadt.de, H.Klingbeil@gsi.de

doi:10.15120/GR-2014-1-FG-SIS18-02