Progress with the barrier bucket system for ESR *

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Introduction

A new barrier bucket system is designed for the ESR storage ring at GSI. It will be used to precompress or to stack the beam longitudinally [1]. The core part of the system are the RF cavities where single-sine voltage pulses with defined amplitude $\hat{U}_{BB}$ and repetition frequency $1/T_{rev}$ have to be generated . These RF pulses are used as potential barriers. To compress the beam one of the pulses is shifted in time (see figure 1).

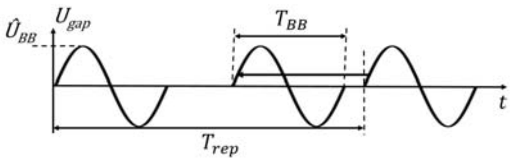

Figure 1: Shifting of the single sine pulses

To achieve pulses with the required high quality a model of the pulse generation system is essential. So in the last year we put efforts into the improvement of a PSpice cavity model and into the nonlinear behavior of the amplifier for high voltage amplitudes.

PSpice model of the cavity

In last year's scientific report [2], we presented a method how to systematically generate an equivalent circuit model for broadband cavities from ring core measurement data. The transfer function of these models showed good agreement with measurements, but the measured impedance still differed from simulation results. In order to improve the model, the coupling windings (see figure 2) were modeled more accurately by a two conductor transmission line and an ideal coupler. The transmission line parameters were estimated analytically from winding geometry and ring core properties.

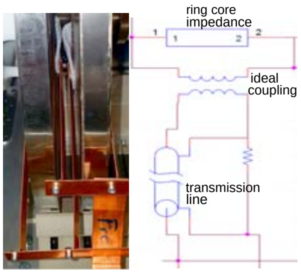

Figure 2: Cavity windings and PSpice model

* Work supported by GSI
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The refined modeling decreased the difference between measurement and simulation of the impedance (see figure 3) and improved the accuracy of the simulated transfer function even further.

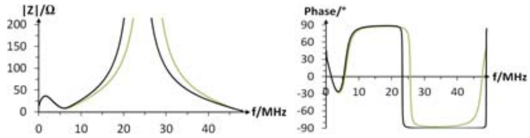

Figure 3: Impedance, comparison beetween measurement and simulation.

Operation in the nonlinear range

As pointed out in the last GSI annual report [3] it is possible to generate single sine gap signals of high quality in a wide voltage range (up to 550 V) by using linear methods. However at high amplitudes, nonlinear effects can be observed and have to be taken into account. Arguing from the setup structure, it is reasonable to assume a static nonlinearity located right after the amplifier entrance. In a first attempt, we determined the nonlinearity by measuring the peak of the gap voltage for sine input signals of different amplitude and smoothened the obtained characteristic by a 4th order polynomial. Figure 4 shows that taking the nonlinearity of the amplifier into account improves the quality of the output signal. Now, amplitudes of up to 760 V can be generated with the same setup and good signal quality.

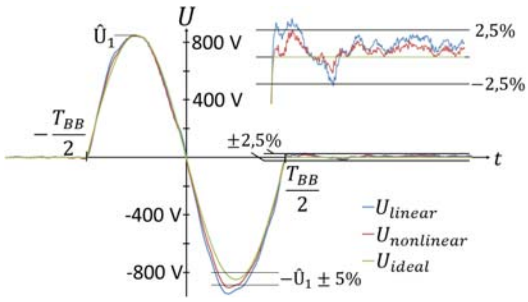

Figure 4: Linear and nonlinear predistortion for $\hat{U} = 820\,\mathrm{V}$

References

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[3] M. Frey, et al., "Status of the Barrier-Bucket system for the ESR", GSI SCIENTIFIC REPORT 2015

DOI:10.15120/GR-2017-1
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