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Dynamic Modeling and Simulation of LER-HER PEP II Rings

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This paper presents the dynamic model and simulation of the beam-cavity interactions in both LER and HER rings at PEP II. The motivation for development of this toll is to explore the stability margins and performance limits of PEP II LLRF systems at higher currents and possible upgraded RF configurations.
The simulation is a time-domain model, so that nonlinear elements in the klystron and
processing can be included. The ring current is represented by macro-bunches, with time structure consistent with the time resolutionof the simulation and necessary modal frequency resolution to explore coupled-bunch modes within the RF system bandwidth.
The program has been validated with data collected from PEP II and SPEAR. Measured transfer functions of the cavity and control system are compared with the simulation results to show the agreement between both results. Measured grow rates for the beam in different conditions at PEP II and SPEAR rings are compared with the preliminary grow rate predictions using the simulation.

Summary

This paper presents the dynamic model and simulation of the beam-cavity interactions in both Low Energy Ring (LER) and High Energy Ring (HER) at PEP II. The motivation for development of this toll is to explore the stability margins and performance limits of PEP II LLRF systems at higher currents and possible upgraded RF configurations. In addition, it will serve as test bed for new control algorithms and
strategies. The goal is to develop a simulation tool that allows understanding the impact of new LLRF processing functions in each RF station such as complex comb loops, klystron linearizers including limitations, etc. as well as better define the ultimate limits of the architecture and implementation.

The program, based on the singular perturbation concept, captures the dynamical behavior of the system based on a reduced model valid at a time-scale where the beam-cavity interaction occurs, and considers in that time frame, the slow dynamics as a constant in the model formulation. The simulation is a time-domain model, so that nonlinear elements in the klystron and processing can be included. The ring current is represented by macro-bunches, with time structure consistent with the time
resolutionof the simulation and necessary modal frequency resolution to explore coupled-bunch modes within the RF system bandwidth. The effect of multiple RF stations in the ring is represented via one or two single macro-cavities. Each macro-cavity capture the overall behavior of all the RF stations composed by two or four cavities, respectively. This allows modeling of the principal longitudinal

impedance control loops. The macro-cavities interact with a longitudinal beam model to study the effects of bunch interactions.

This work is in progress and the program has been validated with data collected from PEP II and SPEAR. Measured transfer functions of the cavity and control system are compared with the simulation results to show the agreement between both results. Measured grow rates for the beam in different conditions at PEP II and SPEAR rings are compared with the preliminary grow rate predictions using the simulation.

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