TIME-DOMAIN SIMULATION SOFTWARE FOR THE APS STORAGE RING REAL-TIME ORBIT FEEDBACK SYSTEM UPGRADE

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Abstract: The APS storage ring real-time feedback (RTFB) system will be upgraded as part of the Advanced Photon Source (APS) Upgrade project. The time domain simulation software is implemented to find the best parameters of correctors and evaluate the performance of different system configurations. The software includes two parts: the corrector noise model generator and the RTFB simulation. The corrector noise model generates the corrector noise data that are the input for the RTFB simulation. The corrector noise data are generated from the measured APS BPM turn-by-turn noise data, so that simulation actually reproduces the real machine. This paper introduces the algorithm and high-level software development of the corrector noise model generator and the RTFB simulation.

Introduction

The existing APS has two feedback orbit correction systems:

- Slow orbit correction using slow correctors is effective up to 1 Hz.
- Fast orbit correction: 60Hz horizontal and 100 Hz vertical, bandwidth up to 800 Hz.

The upgraded system will integrate the two systems into one and increase the sampling rate from 1.5 kHz to 22.6 kHz. The simulation is broken into two pars:

- The noise model uses the turn-by-turn data from FPGA[1] BPMs to model real orbit motion in the storage ring.
- The feedback simulation then takes the modeled open loop beam motion calculated from the noise model as input to test various algorithms and corrector-BPM configurations.

Corrector Noise Model

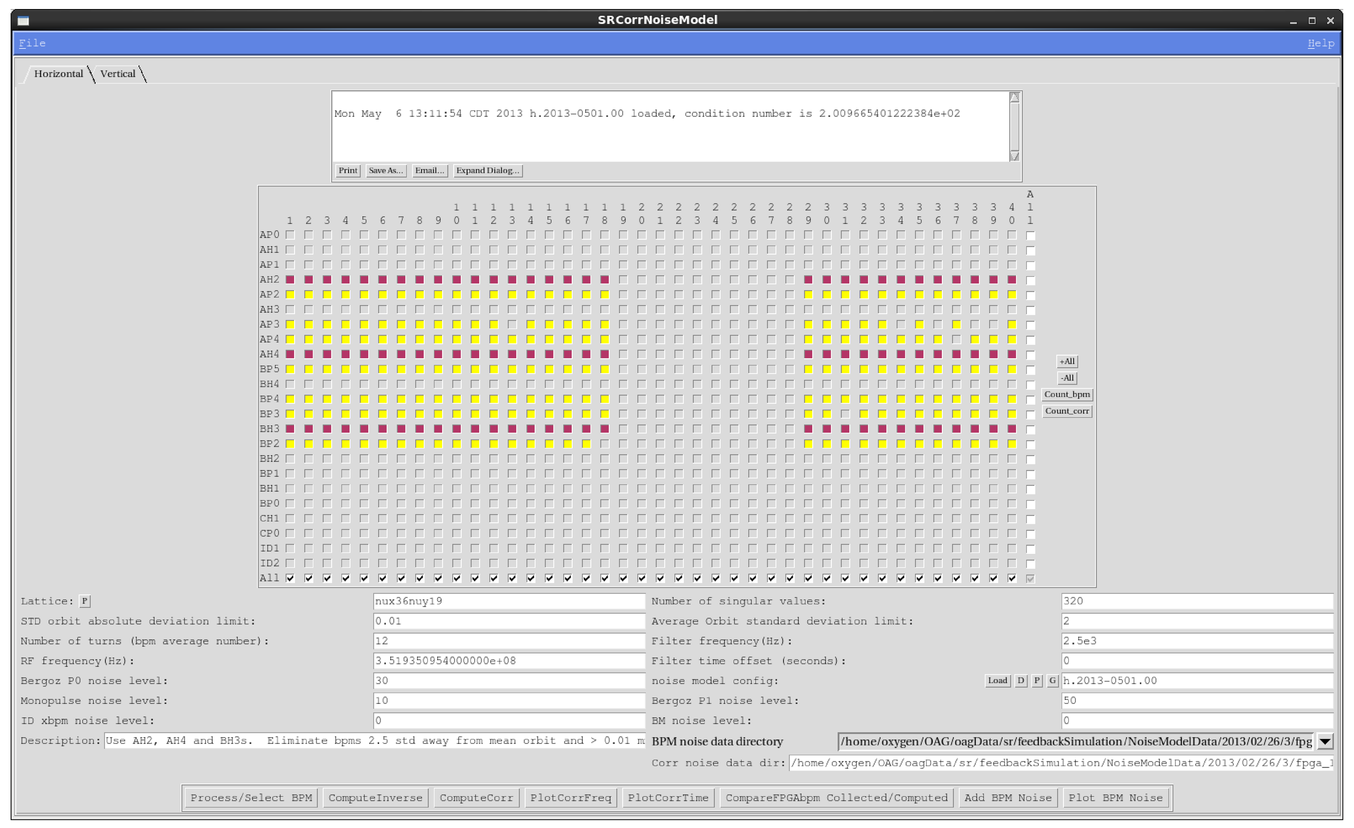

Figure 1 GUI of corrector noise model

1. Process measured FPGA bpm turn-by-turn noise data, select the good BPMs
2. Compute the corrector turn-by-turn drive settings with IRM (inverse response matrix) and the measured BPM turn-by-turn data.
3. Compute the beam position at every BPM with corrector drive and RM (response matrix). The computed beam positions will be used in the feedback simulation

Time-domain RTFB Simulation

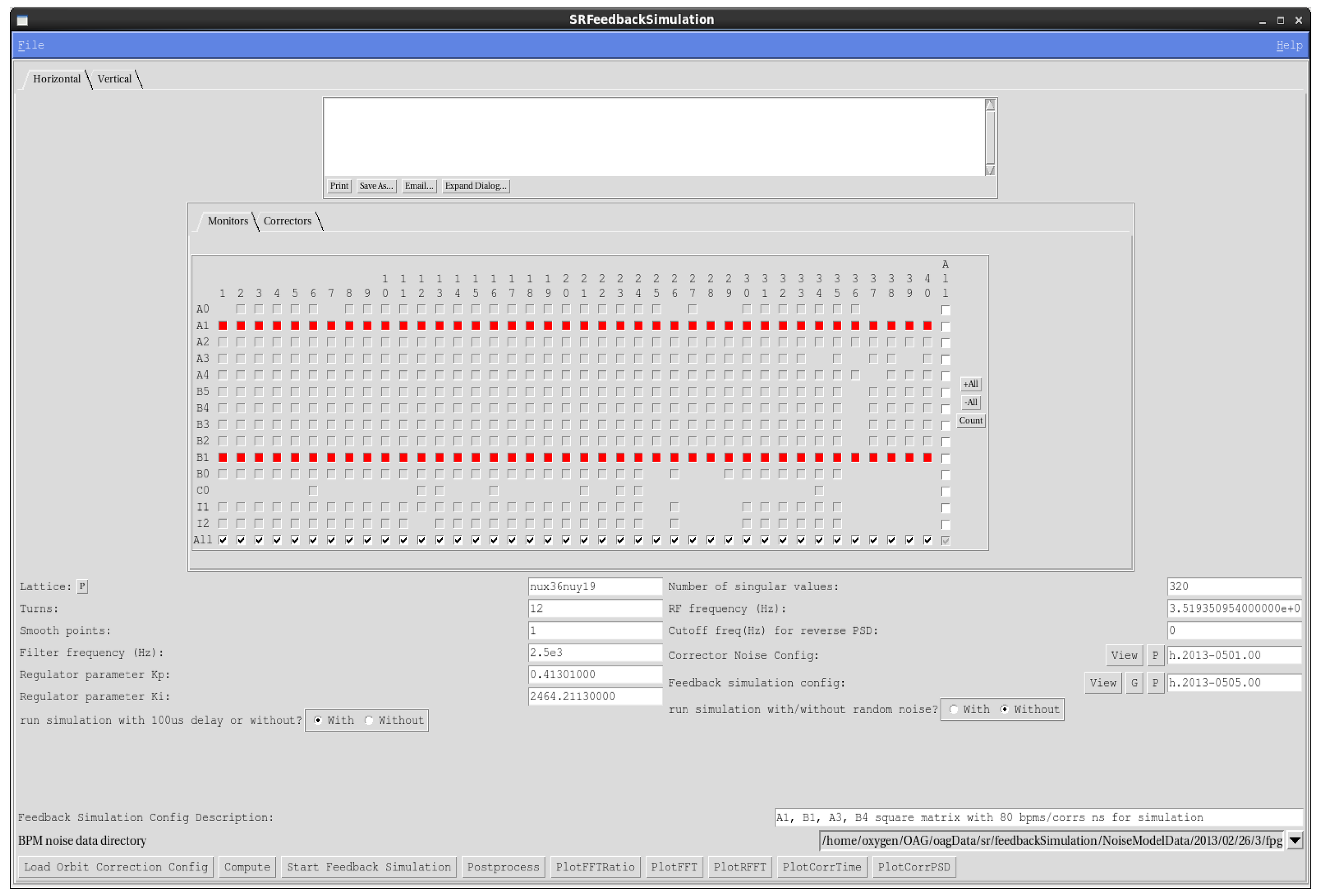

Figure 2 Feedback simulation GUI

Features:

- uses a user-selectable configuration of correctors and BPMs
- Uses OCTAVE script to compute the corrector regulator coefficients from the measured corrector transfer function in the frequency domain along with the regulator's control parameters Kp and Ki.
- added corrector time delay to the time-domain regulator coefficients to study the impact of corrector time delay on the feedback system

Simulation Results

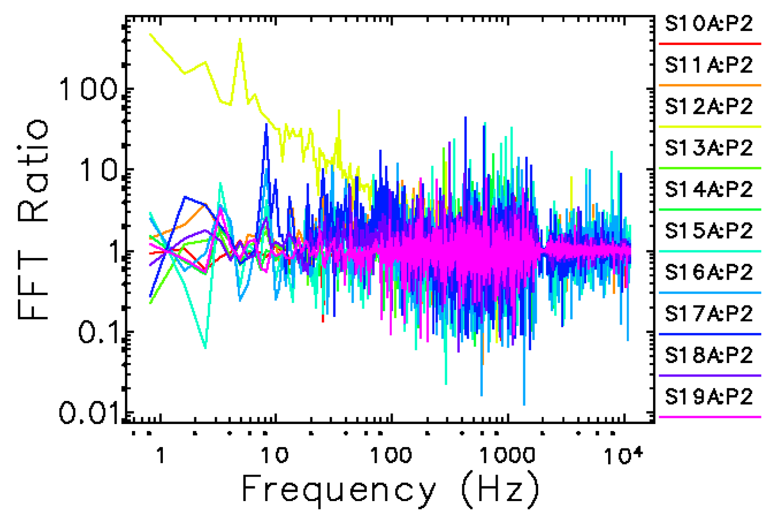

Figure 3 The FFT ratio of the raw v.s corrected orbit at some APS A:P2 BPMs using feedback configuration of one corrector (S12A:H3) and one BPM (S12A:P2).

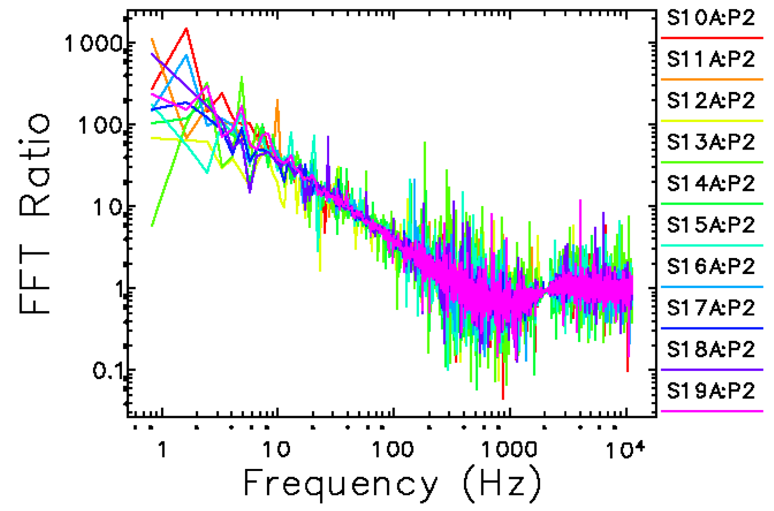

Figure 4 The FFT ratio of the raw v.s corrected orbit at some APS A:P2 BPMs using feedback configuration of 78 corrs. And 78 BPMs

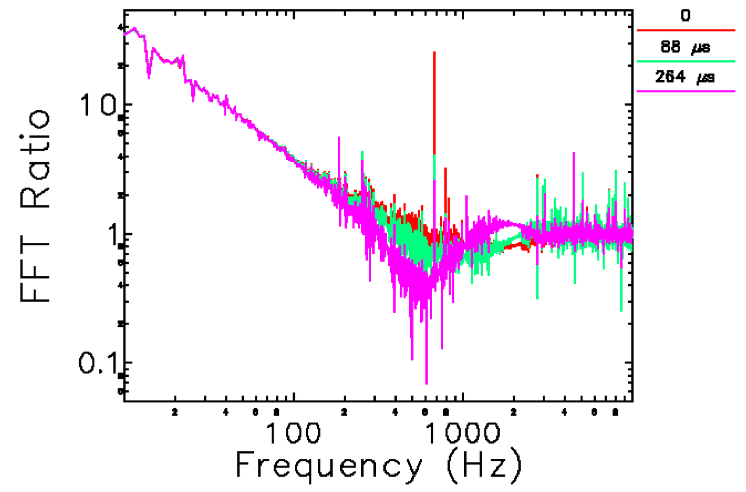

Figure 5 The FFT ratio of the raw v.s corrected orbit of APS horizontal S10A:P2 BPMs at different delays.

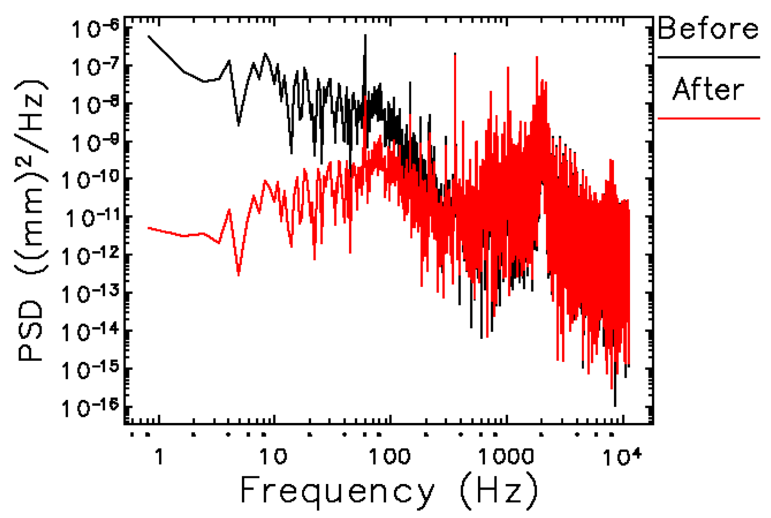

Figure 6 The PSD of APS horizontal S10A:P1 BPM before and after feedback correction.

Summary:

- The feedback correction is up to 200 Hz with 22.6 kHz sampling rate with various configurations.
- As the corrector time delay increases, orbit motion increases in a band from 200 Hz to 1 kHz.
- The PSD analysis shows that the feedback correction is able to correct the orbit up to 500 Hz.
- The simulation can model the corrector response as well as allow us to tune regulator control parameters Kp and Ki for optimum orbit motion suppression.

References:

[1] H. Shang et al., Proc. ICALEPCS 2009, p. 167(2009).