THPAB258

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# STATUS of TIME-DOMAIN SIMULATION FOR FAST ORBIT FEEDBACK SYSTEM AT THE HEPS

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**Abstract:**

High Energy Photon Source (HEPS) is a complex designed at ultra-low emittance. Fast orbit feedback system is proposed to meet the requirement of beam orbit stability at sub-micron level. In this paper, we present our work on setting up an orbit feedback process combined with noise model, system modelling and particle tracking in time-domain. RF phase parameter is adjusted together with fast correctors to mitigate the orbit fluctuation due to energy vibration. The preliminary results are shown here. By the following optimization, we hope to provide an effective tool to specify and configure the FOFB system with the simulation.

## INTRODUCTION

The designed emittance of HEPS storage ring is 34-pm. The requirements of orbit stability for HEPS based on 10% of beam size are list in the table. Fast orbit feedback system (FOFB) for HEP is designed to supress the short time motion at the rate of 22 KHz. The effective closed-loop bandwidth is supposed up to 500Hz. In this paper, we will focus on the short time stability, and present our progress on time-domain to configure the specifications of the performance system and evaluate the effectiveness of the feedback system.

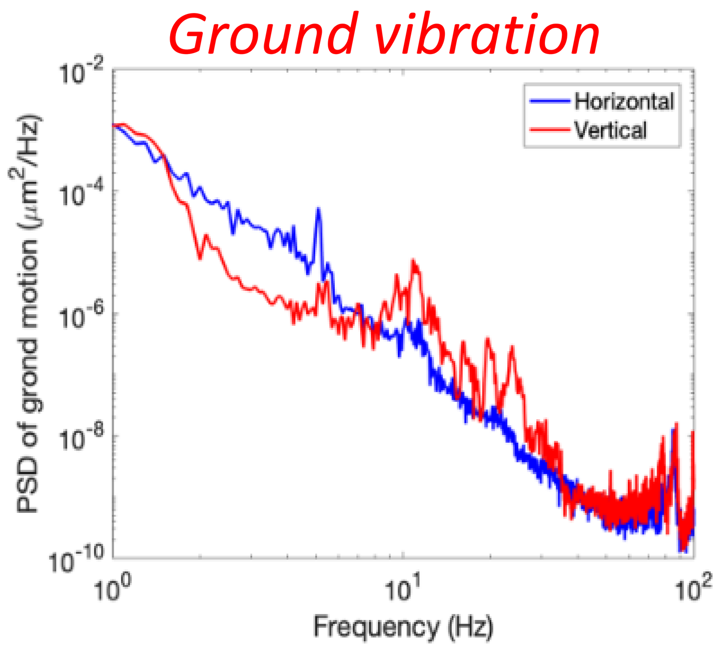
*The stability requirements for HEPS*

| Stability requirements | Short time (0.01-1000 Hz) | |
|---|---|---|
| | Orbit (μm) | Divergence (μrad) |
| Horizontal | 0.94 | 0.2 |
| Vertical | 0.27 | 0.06 |

To implement the simulation, the study is separated into three parts: noise model, performance system modelling and the time-domain feedback code development.

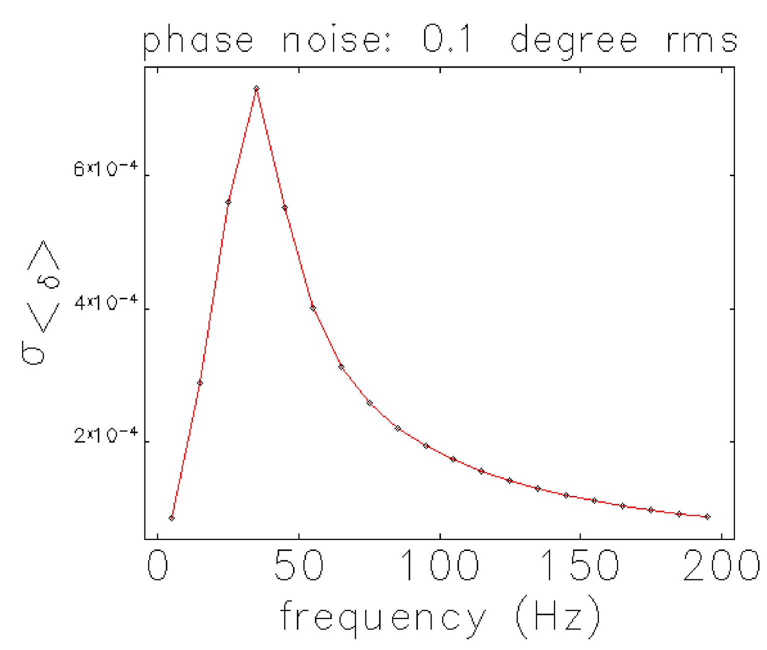
## NOISE MODEL

*Ground vibration*



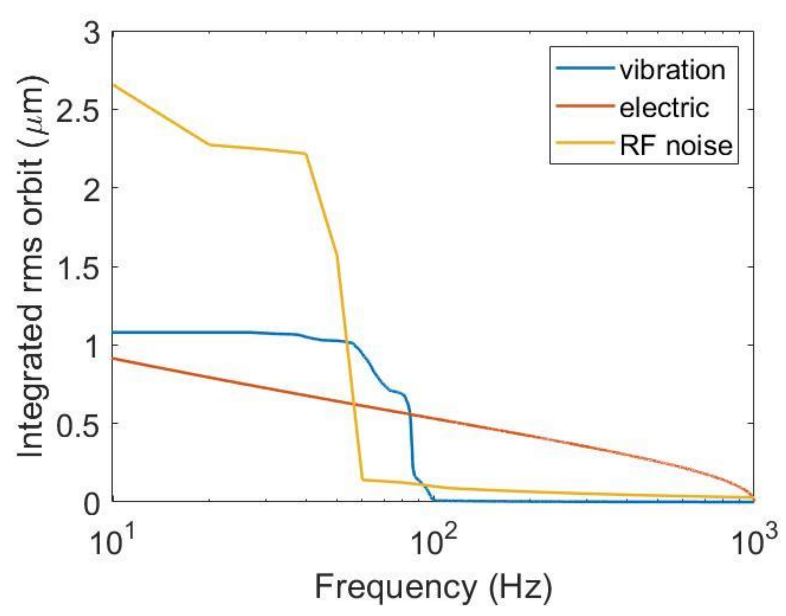

Measurement of HEPS PSD has 1/f [4] dependence (1Hz~100Hz). The RMS amplitudes of ground vibration in the horizontal and vertical plane are 22.8nm and 22.5nm respectively.

*RF system noise*




The RF system noise from AC lines at 50Hz and its harmonic affects beam stability.

*Noise model*




Cumulative RMS motion for different noise model .

## PERFORMANCE MODELLING

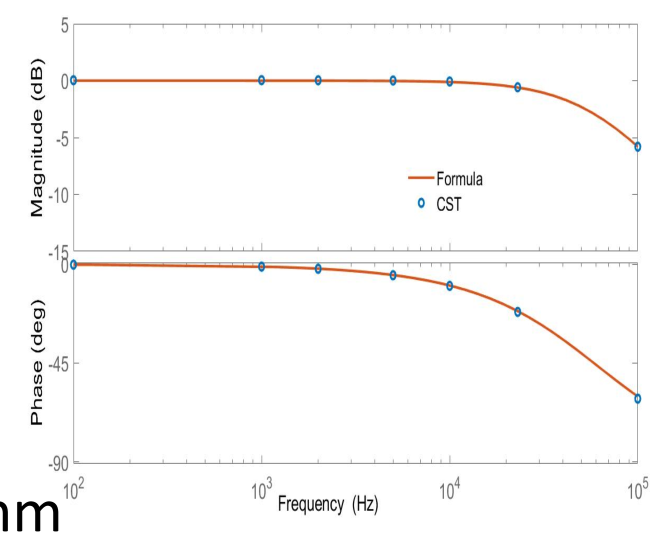
Vacuum chamber

Transfer function in Laplace domain:

$$B_{int}/B_{ext} = \frac{p_0 p_1 p_2}{(p+p_0)(p+p_1)(p+p_2)}$$

$$p_0^{-1} = \frac{1}{2}\mu_0\sigma_c bd, \quad p_{n>0} = -n^2\pi^2/(\mu_0\sigma_c d^2)$$

For HEPS, $\sigma_c$ is conductivity of Inconel , pipe radius $b$ is 11mm, thickness $d$ is 0.5mm




Fast corrector power supply and magnet

Transfer function:

$$G_{cor}(s) = \frac{\alpha}{s+\alpha}$$

To meet the requirement of 10KHz bandwidth, $\alpha$ is about 5 ×$10^4$

Performance system

Transfer function of the orbit error:

$$G_{dist\_reject} = \frac{1}{1 + G_{PI}G_{cor}G_{vam}G_{delay}}$$

$$G_{delay} = e^{-s\tau}$$

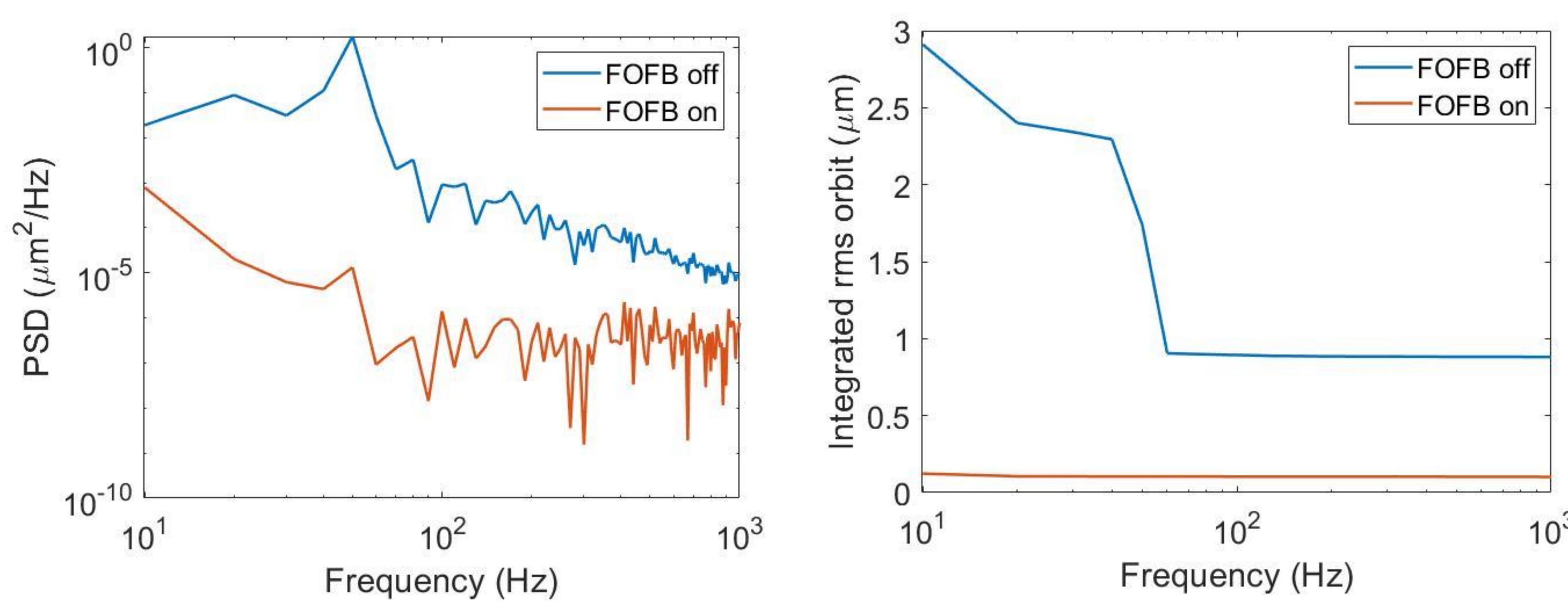
System delay $\tau$ is less than two feedback period.

## TIME-DOMAIN SIMULATION

- Sample the noise model turn by turn.
- Calculate the orbit distortion with multi-particle tracing in AT.
- Ignoring radiation, damping and emission effects, longitudinal motion is included.
- All the 192 (8×24) fast correctors and 384 (16×24) BPMs used.
- Setpoints of fast correctors $\theta_n$ and RF phase $\varphi_{RF}$ are set to the performance system, which is discretized with MATLAB function.

$$\Delta z = R\Delta c \qquad R = (r_1\, r_2 \ldots r_n\, r_{RF})$$
$$\Delta c = (\Delta\theta_1\, \Delta\theta_2 \cdots \Delta\theta_n \;\; \Delta\varphi_{RF})'$$
$$R = USV^T$$

- The outputs of the performance system are set back to the accelerator.
- One loop of the feedback process is complemented.




PSD (left) and cumulative RMS motion with (red) and without (blue) FOFB.

## Summary

The simulation preliminarily implemented the process of orbit feedback combined with longitudinal correction, modelled the performance system, and allowed us to evaluate the effectiveness of the FOFB system when consider the main noise sources. We plan to upgrade the simulation by inducing more accurate model, fine regulator tuning, and improved tracking method next, so as to optimize the FOFB system before the commissioning.

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