COD CORRECTION AT THE PF RING BY NEW ORBIT FEEDBACK SCHEME

K. Harada[?], T. Obina, KEK-PF, Tsukuba, Ibaraki, 305-0801, Japan
N. Nakamura, H. Sakai, H. Takaki, ISSP-SRL, Kashiwa, Chiba, 277-8581, Japan

Abstract

The eigen vector method with constraint conditions (EVC) is the new orbit feedback scheme [1]. When the global COD (closed orbit distortion) correction is made with the EVC, the local orbit correction can simultaneously be done without the deterioration of the global COD correction. We already have successfully confirmed the feasibility of the EVC in the previous machine studies at the PF-AR and the PF ring [2]. After the feasibility demonstration, the performance of the EVC was more systematically studied at the PF ring. In this paper, we present the recent machine study results at the PF ring.

INTRODUCTION

The stabilization of the electron orbit is more and more significant for the user operation at the recent synchrotron light sources. In the PF ring, the vertical electron beam size is so small that the slight change of the COD (closed orbit distortion) affects the intensity of the photon beam delivered to the user beam lines. Moreover, the user recently wants the special insertion devices, for example, such as the tandem circularly polarizing undulators. The appropriate operation of such insertion devices needs the electron orbit modulation. It seems unavoidable that such operation yields the fluctuation of the COD even with the careful design and control. Thus, in addition to the usual orbit feedback for the global COD correction, the fast local orbit feedback is inevitable. There is, however, difficulty in the operation of the independent local orbit feedback system simultaneously with that of the global one due to the interference between two feedback loops. With our new method of the eigen vector method with constraint conditions (EVC) [1], the interference is avoidable in principle, because the EVC has both functions of the global and local COD corrections.

In the previous machine studies at the PF-AR and the PF ring, we already have successfully confirmed the feasibility and the advantages of the EVC [2]. During these machine studies, we generated a vertical COD using one vertical steering magnet and then corrected it using the other ones. Like a local orbit correction method, the EVC well corrected the orbit distortions at the constraint BPMs (beam position monitors). We also confirmed that the constraint condition for the EVC did not deteriorate the orbit distortion at the BPMs without the constraint. The EVC and the EV has almost the same performance in the global orbit correction.

After the machine studies for the feasibility demonstration, we proceed to the systematic study about the performance of the EVC at the PF ring as the next step. In this paper, we present the configuration of the beam diagnostic and the corrector system at the PF ring, and the results of the machine study.

OUTLINE OF THE BEAM DIAGNOSTIC AND THE ORBIT CORRECTION SYSTEM AT THE PF RING

The PF ring is a 2.5GeV electron storage ring of the circumference of 187m. After the upgrade of the straight sections in 2005 [3], there are eight insertion devices in the PF ring. The horizontal correctors consist of the back leg coils of the bending magnets. In order to avoid the complexity due to the large hysterisis and the nonlinearity of them, we focused on the vertical orbit correction in this machine study as well as the previous studies. The configuration of the system is shown in Fig. 1. The PF ring has 65 BPMs and the resolution of the BPMs is very high and is about 1μm or smaller. Other than 42 vertical dipoles (VDs) of the solid core, the PF ring has 28 fast vertical steering magnet of the lamination core for the vertical fast orbit feedback system [4]. The system was almost closed and thus the kick angles of the fast vertical steering magnets were not recorded in the previous studies. From this study, however, they are available through the new control system with the EPICS.

MACHINE STUDY PROCEDURES

At first, we studied the effect of the number of the used eigen vectors on the COD after the correction and the required kick angles of the steering magnets. The vertical COD was generated by each vertical dipole, and then corrected by the fast orbit feedback system as well as the previous studies. The COD was corrected by the EVC and the EV with the two different numbers of the used eigen vectors, 14 and 20. The constraint conditions for the EVC cases were imposed on the both sides of the two insertion devices of ID-02 and ID-19 that are the BPM numbers of 01, 41, 42 and 65. We compared the results with the simulations for the ideal case as shown in Figure 2.

Secondly, we focused on the effect of the used eigen vector number. The number of the eigen vectors was gradually increased from 4 to 28 to correct the two typical cases when the CODs were produced by the VD17 and VD41. The simulation and the measurement results are shown in Figure 3.

Finally in order to examine the long term performance, the fast orbit feedback with the EVC was given for 7 hours under the same condition as the user operation. The

[?]kentaro.harada@kek.jp

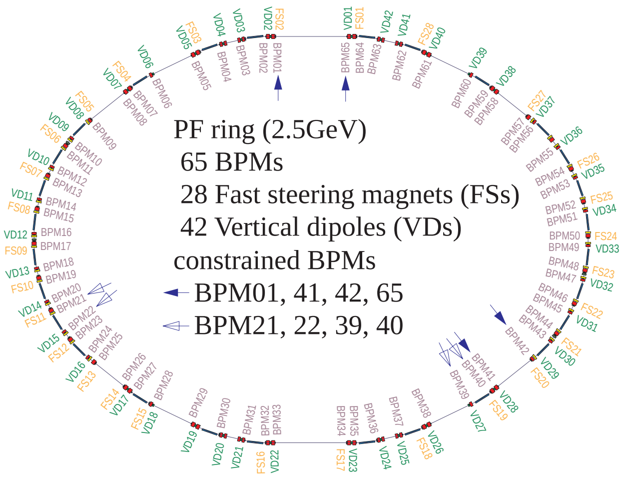

Figure 1: Configuration of the BPM and vertical orbit correction system at the PF ring after the upgrade of the straight sections in 2005.

constrained BPMs were at the both sides of the two bending magnets of B11 and B18 that were the BPM numbers of 21, 22, 39 and 40. The results are shown in Figure 4. The 14 eigen vectors were used for both the EVC and EV as in the user operation.

RESULTS OF THE MACHINE STUDY

Comparing the results of the EVC with that of the EV, the performance of the global COD correction and the required kick angles are almost the same for both cases of 14 and 20 eigen vectors, as shown in Figure 2-(1,2-a,c). As is the case of the previous studies, when the numbers of the steering magnets were not sufficient near the COD source, the large COD was sometimes left after the correction. With the EVC, even when the constrained BPM was next to the COD source, the COD at the constrained points was well corrected. As shown in Figure 2-(1,2-b), the COD at the constrained points for the EVC cases are mathematically zero in the simulation and as small as the resolution of the BPM, below 1μm, in the measurements. When 20 eigen vectors were used, the global COD after the correction became smaller and the required kick angles were larger than those with 14 eigen vectors. The measurement results well agreed with the simulation results in Figure 2.

By increasing the number of the used eigen vectors, although the required kick angles of the steering magnets became larger, the performance of the global COD correction was improved. There was, however, the saturation of the improvement as shown in Figure 3-(1,2-a). The saturation started at about 16 used eigen vectors for the case of VD17, and about 12 for VD41. The saturation of the case of VD17 started at the larger

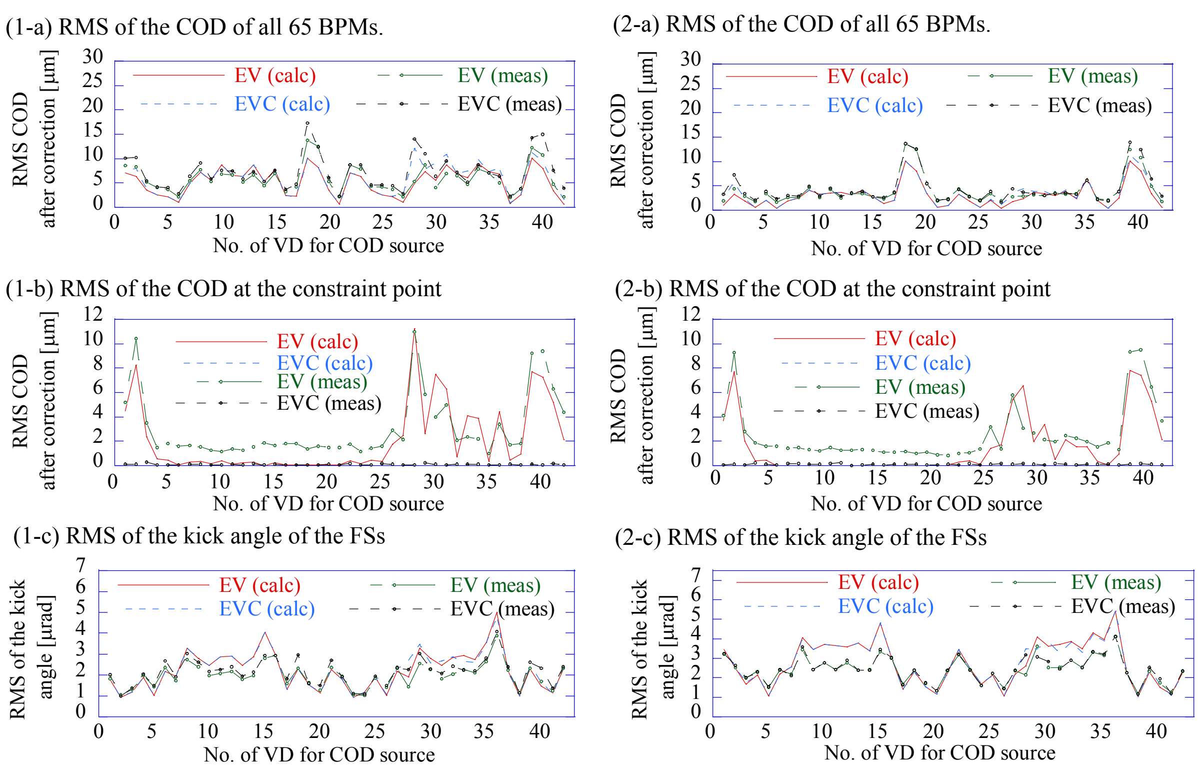

Figure 2: Calculation and the measurement results of the COD correction. The number of the used eigen vectors is 14 for Figures (1-a), (1-b) and (1-c), and 20 for (2-a), (2-b) and (2-c). Figures (1-a) and (2-a) shows the RMS of the COD at the all 65 BPMs and (1-b) and (2-b) that of the constrained BPMs of No. 1, 41, 42 and 65. Figures (1-c) and (2-c) shows the RMS of the kick angles of the fast steering magnets (FSs). In each figures, the lines "EV" show the results with the ordinary eigen vector method, and "EVC" the eigen vector method with the constraint condition. The lines "calc" show the simulation results and "meas" the measurement results.

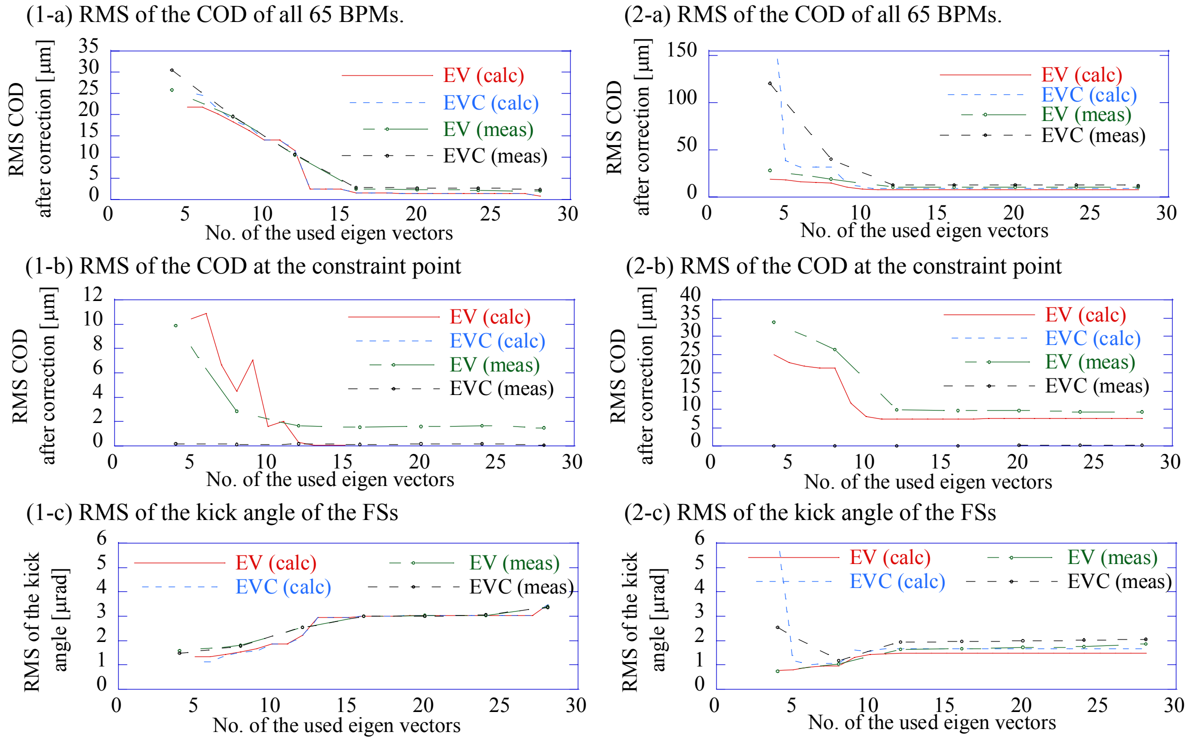

Figure 3: The effect of the number of the used eigen vectors. The source of the COD is VD17 for Figures (1-a), (1-b) and (1-c), and VD41 for (2-a), (2-b) and (2-c). The legends are the same as the Figure 2.

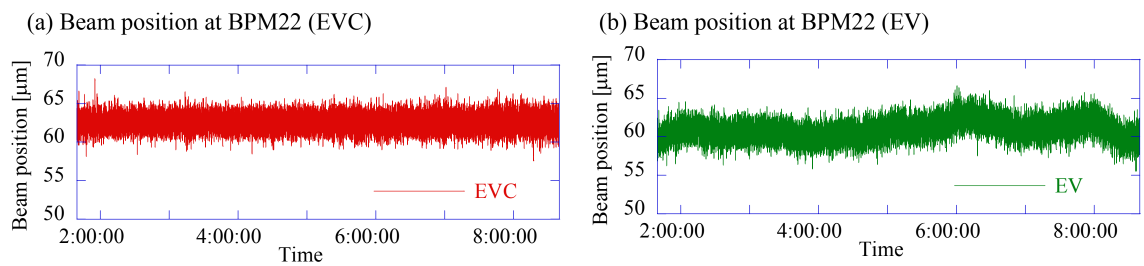

Figure 4: Orbit fluctuation for 7 hours at the BPM22. (a) shows the results with the EVC and (b) that with the EV. The BPMs of No. 21, 22 (shown), 39, and 40 are constrained.

number of the used eigen vectors and the residual RMS COD after the saturation was smaller than those of the case of VD41. There was enough number of the steering magnets near VD17, and the COD could be smoothly corrected. The local COD is always successfully corrected with the EVC regardless of the used eigen vector number and the source position of the COD. The simulation results were consistent with the measurements.

When the number of the used eigen vectors was very small, the large kick angles were sometimes required and the RMS of the global COD after the correction was large for the EVC as shown in Figure 3-2. By increasing the number of the used eigen vectors, the kick angles was reduced and the COD was successfully corrected. The COD correction with the EVC required a certain number of the eigen vectors, which also agreed with the simulation.

For the long term stability test shown in Figure 4, while the small orbit drift was observed during 7 hours with the orbit feedback by the EV, the EVC successfully suppressed the orbit drift.

REFERENCES

[1] N. Nakamura, et.al., “New orbit correction method uniting global and local orbit corrections”, NIM A 556 (2006), pp421-432

[2] K. Harada, et.al., “COD Correction at the PF ring and PF-AR by New Orbit Feedback Scheme”, Proc. of PAC 2005, pp2613-2615

[3] T. Honda, et.al., “Reconstruction of Photon Factory Storage Ring for the Straight-Sections Upgrade Project”, Proc. of PAC 2005, pp2678-2680

[4] T. Obina et. al, ” Global Feedback System For Photon Factory Storage Ring”, Proc. of EPAC98, pp1726-1728