STATUS OF THE SSRF FAST ORBIT FEEDBACK SYSTEM

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Abstract

The fast orbit feedback system with bandwidth from DC up to 100Hz is under commissioning at SSRF. The main purposes of the system are to suppress the short term orbit vibration under sub-micron level and to compensate the orbit distortions caused by changing gaps of the insertion devices. The layout of the system is described and the preliminary commissioning results are given out in this paper.

INTRODUCTION

Shanghai Synchrotron Radiation Facility (SSRF) is a 3rd generation light source based on a 3.5GeV storage ring. The storage ring is composed of 20 double bend achromatic (DBA) cells with circumference 432m and the natural emittance is 3.9nm·rad. There are 140 BPMs along the ring fully equipped with IT Libera electrons. Each cell gets 7 BPMs, among them 2 BPM buttons at the ends of straight sections and 1 BPM button in the arc are mounted on separated chambers linked by two bellows to the rest of the beam pipes and supported by low thermal expansion coefficient stands. Those BPMs are called high precision (HP) BPMs.

There are two orbit feedback systems in the SSRF storage ring. One is slow orbit feedback system (SOFB) which consists of 80 correctors in each plane and 60~80 BPMs according to BPM healthiness, operates at 0.1Hz. The other is the fast orbit feedback systems (FOFB), which is designed to employ 60 air coil correctors and 60 fast acquisition (FA) HP BPMs in the loop. The bandwidth is from DC to 100Hz. At present only 40 correctors are powered and 40 FA BPM is linked.

The requirement of orbit stability is 1/10th of the RMS beam size. Beam sizes are shown in table 1, beam stability in vertical plane should be in sub-micron level and stability in horizontal plane should be less than 5 microns.

Table 1: Beam size at source points (1%coupling) [1]

Location	Horizontal beam size	Vertical Beam size
Standard SS	158μm	9.9μm
Long SS	247μm	15μm
Bend 3°	53μm	22μm

LAYOUT OF THE FOFB

The layout of the FOFB is sketched in Fig. 1[2]. A star topology is used for building an effective transfer system to synchronize the data from different VME crates. Each local station controls 12 FA BPMs (at rate of 10kHz) and 12 corrector power supplies (PS). PMC-8611 is employed to communicate with the central computer through ethernet. The central computer collects BPM readings and calculates PS using SVD method and then transfer the PS setting to the local stations. The local station is in charge of quad digital receiver (QDR) and PID controller. EVG (Micro-research EVG200) and EVR (Micro-research VME-EVR-200-RF) collected by a gigabit fiber channel to synchronize the BPM data. The PID controller is placed after PS calculation as shown in Fig. 2, which will be more flexible as each station can be independent. As derivative term is too sensitive to the noise and will drive the system unstable, the derivative gain is set to zero for the PID controller.

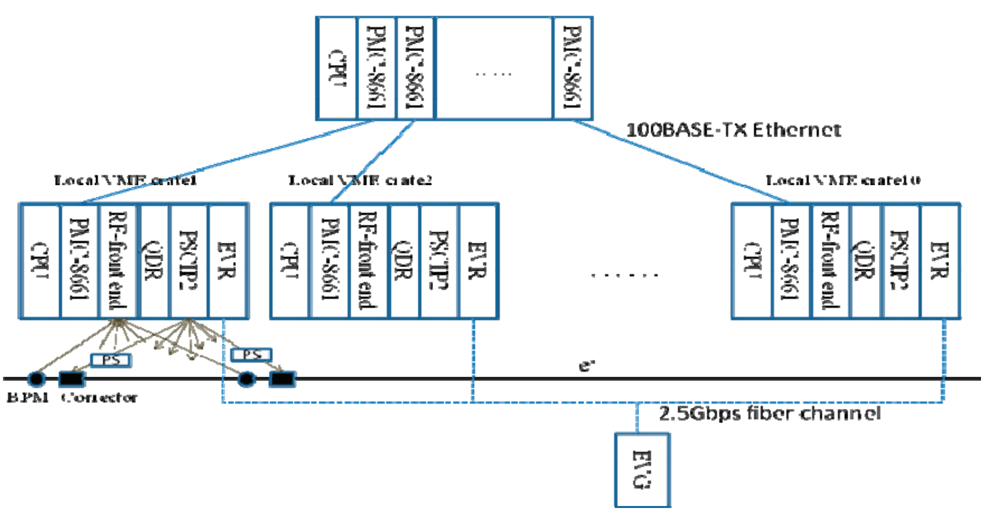

Figure 1: Layout of the SSRF FOFB system.

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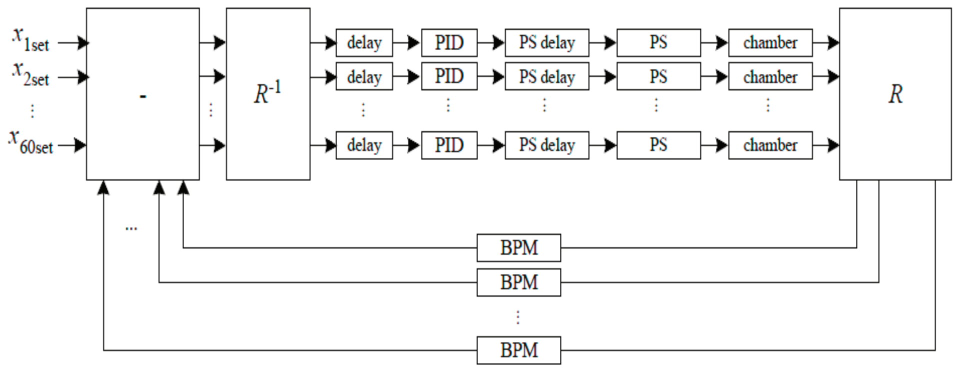

Figure 2: PID control loop.

CROSS TALK BETWEEN SOFB AND FOFB

The air coil correctors for the FOFB system have limited correction strength of 80μrad in horizontal plane and 60μrad in vertical plane, the FOFB power supply will saturate in a few hours when operated alone. The solution is operating both SOFB and FOFB simultaneously. As the two systems act independently and there's overlap of frequency band, communicates is needed between them [3]. FOFB should be told when SOFB is correcting the orbits and this correction should not be treated as an orbit distortion by the FOFB. In this way every time SOFB act, the golden orbits are updated for the FOFB system and the strength of FOFB corrector will be partly transferred to SOFB.

As not all 140 BPMs are controlled by SOFB, the orbits at which places BPMs are not in SOFB loop will have larger oscillations through SVD algorithm. The choice of FOFB BPMs should be the subset of the SOFB BPMs to avoid FOFB correcting such large orbit distortion caused by SOFB.

In vertical plane the response matrix eigen value used for SOFB is only 40. As shown in Fig. 3, the eigen value over 40 is relative too small and will result SOFB undesirable sensitivity to BPM noise. In the commissioning, orthogonal mode to those 40 eigen vectors can be build up by FOFB correctors and can't be corrected by the SOFB system. The results are FOFB PS drift away and eventual saturate; the orbit drifts caused by the FOFB correctors increased and could not corrected by the SOFB. According to these orthogonal modes, the cross talk between FOFB and SOFB fails through updating golden orbit as mentioned above. Additional treatment needs to remove parts of the FOFB PS value in the vertical plan. The trade off for two systems operation is that eventual orbit stability depends on SOFB, the FOFB only fight against fast orbit vibration between 10s intervals of SOFB actions.

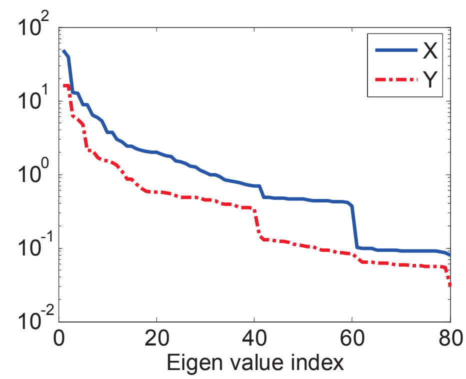

Figure 3: Matrix eigen value for SOFB.

COMMISSIONING RESULTS

The FOFB is commissioned together with SOFB. The BPM number in FOFB loop is 32 and the corrector number is 38 for each plane. Eigen value number is 22 and 18 for horizontal and vertical plane respectively. The reverse response matrix are highly correlated as shown in Fig. 4 similar to SLS case[4] which means the orbit distortion is mainly corrected by the adjacent correctors where distortion makes.

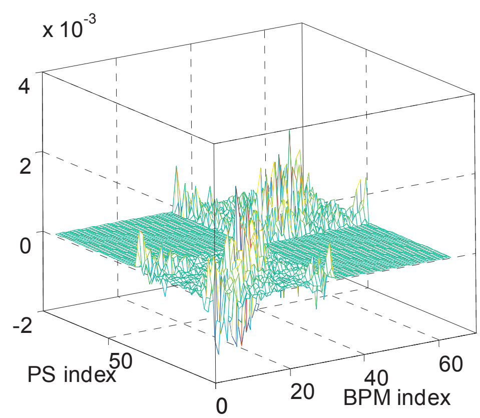

Figure 4: Reverse response matrix for FOFB.

System Robustness

The cross talk between SOFB and FOFB enables orbit feedback systems stable working for hours under top up operation mode. Fig. 5 shows 10 hours FOFB PS setting growth. As the maximum PS setting can be 10A. The systems could expect to stable work hundreds of hours without saturation.

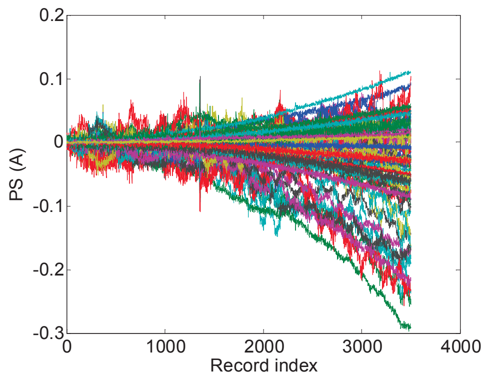

Figure 5: FOFB PS growth.

Beam Stability

As mentioned in the above section, the final long term orbit stability depends on SOFB. Fig. 6 shows the SOFB panel, recording orbit stability in both horizontal and vertical plane. The RMS orbit stability in horizontal plane is 0.82μm and for vertical plane is 0.86μm .

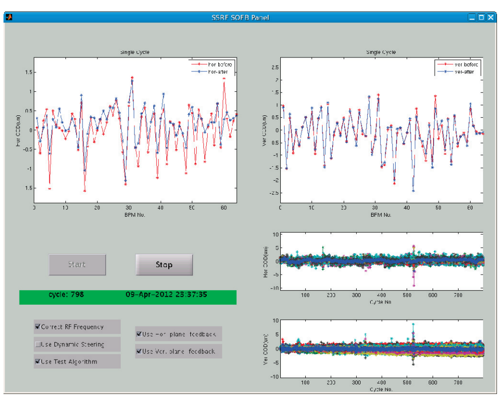

Figure 6: SOFB panel.

Fig. 7 shows vertical displacement PSD of the beam motion comparing FOFB switched on and off as well as ground, quadrupole, girder and chamber motions. The beam motion up to 20Hz can be suppressed obviously.

The main peak of the beam motion is at 24Hz and 48~50Hz, at which frequency FOFB works not so perfect. The integrated PSD up to 100Hz for FOFB off and on is 0.72μm and 0.61μm respectively.

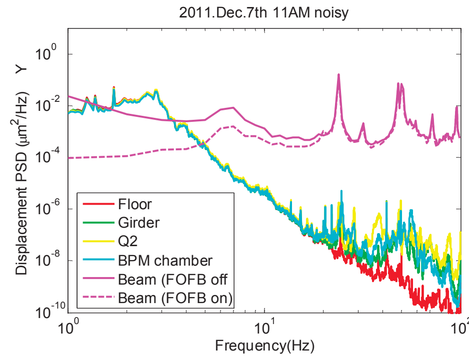

Figure 7: Vertical displacement PSD.

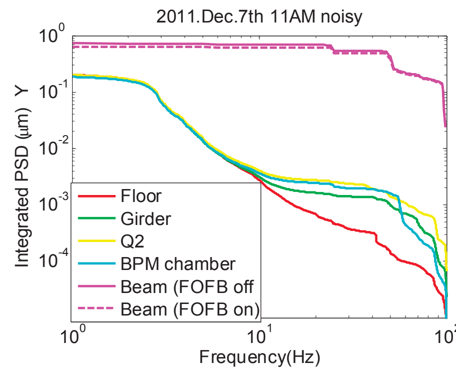

Figure 8: Vertical integrated displacement.

UPGRADE PLAN

The action to make FOFB systems fully equipped is on the way. The system with 60 corrects and 60 BPMs will available at the end of this year. The more number of the correctors, the stronger capability will be of the correction. The more number of the BPMs, the more tolerance will be to the noise of the system.

The Libera electrons will be replaced by the Brilliance ones. With Grouping tech, mismatching of the data in transfer will be solved. And we expect to improve the suppression capability at 24Hz and 48~50Hz.

The PID coefficient together with SVD algorithm will be carefully tuned to pursue higher performance for the full equipped FOFB systems.

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