CLOSED ORBIT CORRECTION IN THE HIGH FIELD LATTICE OF THE ILSF STORAGE RING*

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Abstract

Several corrector magnets have been distributed in the design stage of the high field ILSF storage ring lattice to correct the distorted closed orbit due to the errors. Moreover, the beam position monitors (BPM) in the straight sections and between the magnets are used to observe the corrected orbit. We used the SVD method with ELEGANT [1] code for closed orbit correction. This paper gives results of closed orbit correction in the ILSF storage ring and stipulates the required strength of the correctors.

INTRODUCTION

According to the several submitted request proposals from the users to have high quality x-ray pulses, government of Iran has been convinced to build an intermediate energy synchrotron light source with several beamlines [2-4]. The Iranian Light Source Facility (ILSF) project is a new 3 GeV third generation synchrotron light source which is currently in design stage and will be built in Iran. To have a competitive leading position in the future, storage ring of the ILSF is designed to emphasize small emittance electron beam, great photon flux density, brightness, stability and reliability. Moreover, to have several straight sections of different lengths to accommodate various required insertion devices, a four-fold symmetric ring with 32 straight sections was found. Circumference of the storage ring is 297.6 m and electron beam emittance is 3.278 nm.rad. The linear lattice functions are well matched to the requirements of a small emittance and a small beam size at the radiators. Nonlinear part of the lattice has been optimized to provide large stable physical space for the electron beam. The storage ring main parameters are given in Table 1 and for more information, the reader is recommended to see Ref [2-6]. The four-fold symmetric configuration provides 4 long, 16 medium and 12 short straight sections with the length of 7.88 m, 4 m and 2.82 m respectively. The ratio of the total length of the straight sections to the circumference of the ring (percentage of storage ring) is 43.46% which is pretty good in comparison with other light sources.

Table 1. Main parameters of the high field ILSF storage ring.

Parameter	Unit	Value
Energy	GeV	3
Beam current	mA	400
Symmetry	-	4
Circumference	m	297.6
Natural emittance	nm.rad	3.278
Harmonic number	-	496
RF frequency	MHz	500
Natural energy spread	-	1.04×10^{-3}
Tune (Q_x/Q_y)	-	18.26/11.32
Natural chromaticity (ξ_x/ξ_y)	-	-34.56/-28.02
Momentum compaction (α_c)	-	7.62×10^{-4}
Radiation loss per turn	MeV	1.01
No. of dipoles	-	32
No. of quadrupoles	-	104
No. of sextupoles	-	128

However, there are many sources of errors in the high intensity storage rings which can cause closed orbit distortion (COD). One of the sources of COD is error in the field of dipole magnets which kicks out the electrons. Other sources of COD are displacement and roll of the magnetic elements which can be caused by girder deformation or misalignment of the magnets. The most severe effects come from the misalignment of quadrupoles where the resulting dipole field is proportional to the both gradient and misalignment errors.

CLOSED ORBIT DISTORTION

To study the total effect of errors on the closed orbit, different types of the expected misalignments and field errors were imposed randomly in the lattice of the ILSF storage ring. The errors listed in Table 2, have been utilized in our calculations. The relative field error of 1×10^{-4} is also assumed in the dipoles. In reality, the magnets are first installed on the girder and then moved inside the storage ring tunnel. Therefore, the misalignment between the girders is assumed to be larger than that of inside the girder.

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Table 2. The utilized errors for the COD calculation.

Type of error	Value
Displacement and roll of dipole with respect to girder	$\Delta x=\Delta y=30$ µm $\Delta\varphi=100$ µrad
Displacement and roll of quadrupole with respect to girder	$\Delta x=\Delta y=30$ µm $\Delta\varphi=100$ µrad
Displacement and roll of sextupole with respect to girder	$\Delta x=\Delta y=30$ µm $\Delta\varphi=100$ µrad
Displacement and roll of BPM with respect to girder	$\Delta x=\Delta y=30$ µm $\Delta\varphi=100$ µrad
Girder transverse displacement and roll	$\Delta x=\Delta y=30$ µm $\Delta\varphi=100$ µrad

The distorted orbit has been numerically evaluated based on the SVD method with ELEGANT [1] code is shown in figure 1.

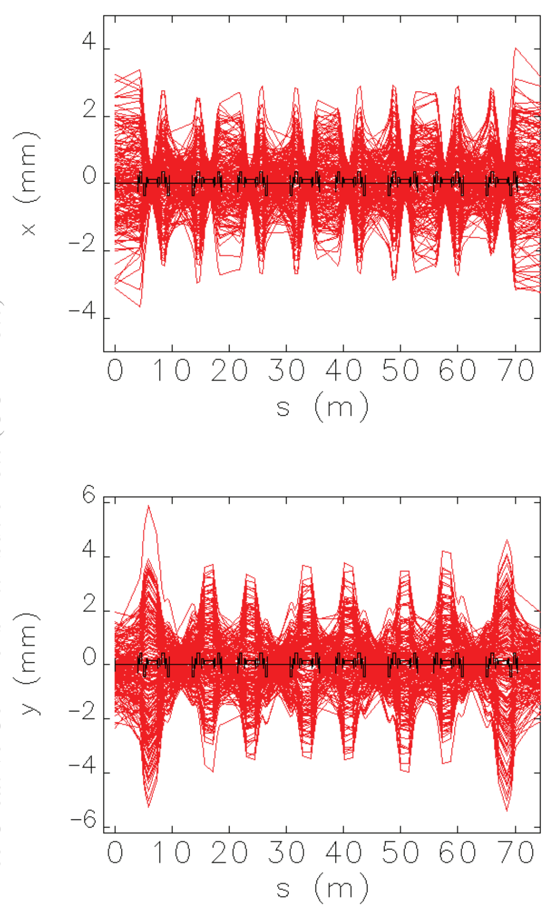

Figure 1. Distorted closed orbit in a super period of the storage ring for 200 seeds random errors, horizontal orbit (top), vertical orbit (bottom).

CLOSED ORBIT CORRECTION

128 horizontal and 128 vertical corrector coils in each plane of the sextupole magnets have been used around whole of the ring to correct the COD. Moreover, we have distributed 128 BPMs to observe the beam coordinate and study its orbit. The BPMs need to be located at crucial points. They have been placed near the quadrupoles to minimize the COD, near the sextupoles to decrease the feed-down effects and at both ends of each straight section to improve the control of stable light sources from insertion devices. Location of the BPMs and the HV correctors in a super period of the ring is shown in figure 2.

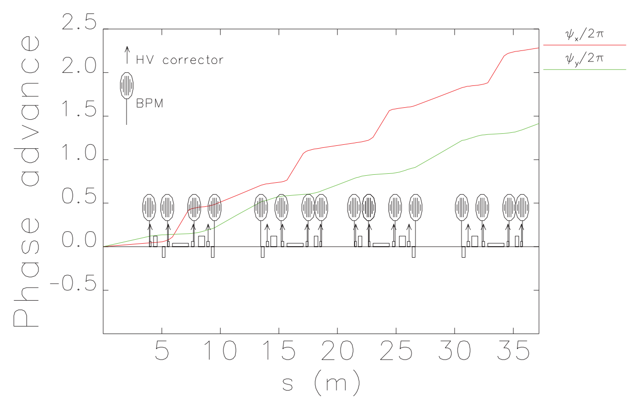

Figure 2. Location of the BPMs and the HV correctors in half a super period of the ring.

The corrected closed orbit in the storage ring is depicted in figure 3 which reveals that the distorted orbit is corrected to less than 150 µm in transverse plane. The corresponding strength of the corrector magnets is shown in figure 4 that indicates the maximum strength of the correctors used for orbit correction is 0.3 mrad.

CONCLUSIONS

To study the effects of the errors on the closed orbit and to find the optimum position and strength of the correctors and the BPMs in the ILSF storage ring, different types of expected errors have been randomly distribute. The results indicate that the orbit will be corrected to below than 150 µm in transverse plane by the use of 128 HV orrectors in each sextupole and 128 BPMs. The results show that the maximum strength of correctors would be 0.3 mrad.

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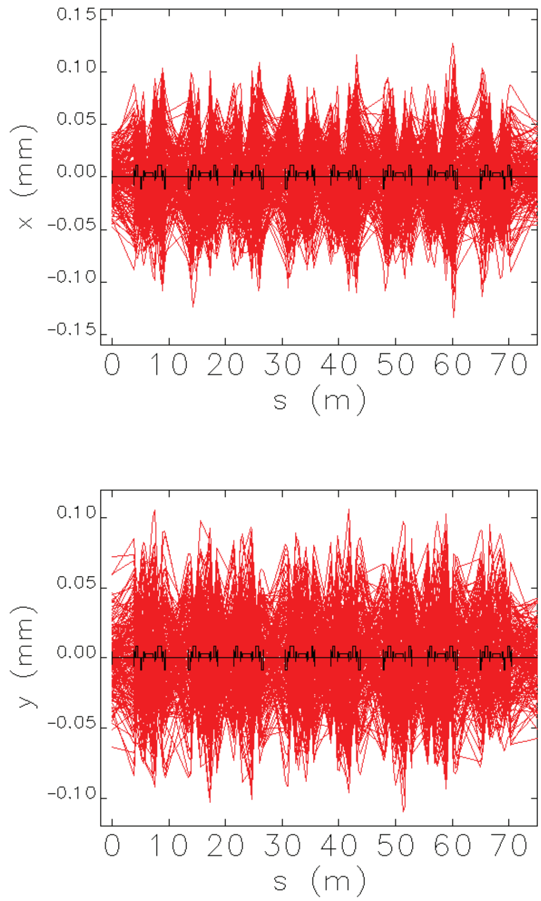

Figure 3. Corrected closed orbit in a super period of the storage ring for 200 seeds random errors, horizontal orbit (top), vertical orbit (bottom).

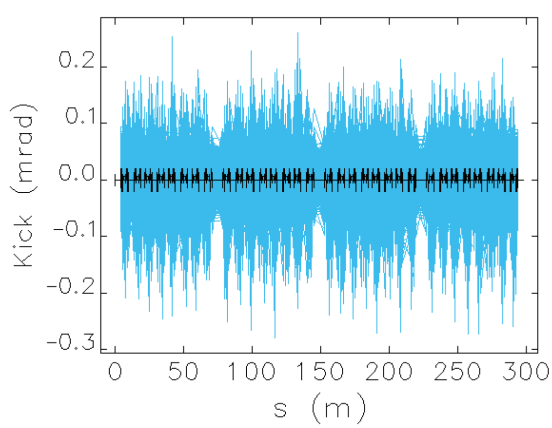

Figure 4. Strength of the corrector magnets in the ring for 200 seeds random errors.

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