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A POSSIBLE EMITTANCE REDUCTION SCHEME FOR PLSII*

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Abstract

As the upgrade of PLS, PLSII is a 3 GeV light source in 12 super-periods (281.8 m circumference) with 5.8 nm design emittance and can store electron beam up to 400 mA with 3 superconducting RF cavities. PLSII lattice is a double bend achromatic (DBA) lattice with 2 straight sections for each cell (24 straight sections). After completion of PLSII, multi-bend achromatic lattice has been widely adopted to accomplish low emittance. This paper discusses how a minimal change can modify the PLSII's DBA to a quadruple bend achromatic (QBA) lattice and reduce the emittance to about a half value.

INTRODUCTION

Construction of PLS (Pohang Light Source) was completed in 1994 and began operation for users in 1995, as a 2 GeV light source with a 12 super-period TBA (triple bend achromatic) lattice giving 12.1 nm rad beam emittance. Later, the PLS electron energy was raised to 2.5 GeV to expand the capacity for hard X-ray emission with the same lattice, which raised the emittance to 18.9 nm rad. In 2011, PLS was upgraded to a 3 GeV light source PLSII in the same storage ring tunnel but with the new lattice. The new lattice adopted DB (double bend) type and was designed to give 5.8 nm rad emittance. Main parameters of PLSII are listed in Table 1.

Table 1: Main Parameters of PLSII Storage Ring

Parameter	Value
Energy	3 GeV
Current	400 mA
Emittance	5.8 nm
Circumference	281.82 m
Tune (h/v)	15.24 / 9.17
Revolution freq.	1.0638 MHz
Harmonic No.	470
RF freq.	499.973 MHz
Cavity type	SC
No. of Cavities	3
Gap Voltage	4.5 MV

PLSII Lattice

The most unique feature of PLSII is that there are two straight sections, a long straight section (LSS) and a short straight section (SSS), for each of the 12 cells, to install as many insertion devices (IDs) as possible. The 6.88 m long LSS is long enough to accommodate the injection system as well as long IDs while the 3.1 m SSS accommodates short IDs. Dispersion is non-zero in both LSS and SSS as can be seen in Fig. 1 which illustrates the PLSII lattice. In order to make this big portion of empty space on the 281.82 m ring circumference, the number of magnets used was minimized and so only 8 quadrupoles are used in a cell while gradient bending magnets are used. Also, 4 sets of sextupoles are used for chromaticity correction to suppress head-tail instability and for harmonic correction to enlarge the dynamic aperture. Since the completion and commissioning, PLSII has been operated smoothly in the current range of 300~400 mA.

As a price for the unique feature of having two insertion straights and low electron beam emittance, PLSII has relatively high dispersion values on the two straight sections (0.25 m at LSS and 0.14 m at SSS), which increases the effective emittance of the two insertion straights.

After upgrade completion, PLSII has raised its performance step by step and achieved all design goals. It is providing the 300~400 mA top-up service routinely in the submicron rms orbit stability [1].

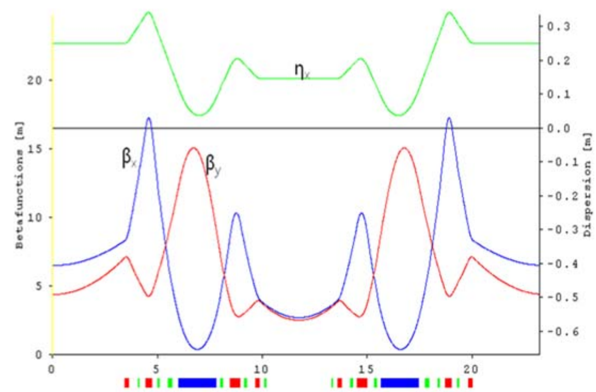

Figure 1: PLSII lattice.

Advent of Multi-bend Lattices

In the meantime, the multi-bend achromatic lattice has been widely accepted by the light source community of the world to obtain even lower (sub-Nano scale emittance or even to the diffraction limit) emittance. While new proposals for sub-Nano scale emittance are made, there are also plans to upgrade existing machines to sub-Nano scale emittance machines.

Motivated by this trend, this paper discusses a possibility that the PLSII lattice can be made a multi-bend lattice through a minimal change leaving the many IDs unchanged and consequently the electron emittance can be reduced substantially. It will be shown below that the DB lattice can be changed to a quadrupole bend (QB) lattice only by adding two gradient bending magnets and two quadrupole magnets in each LSS without changing the original PLSII lattice at all. This way, the electron beam emittance can be reduced to about a half value.

NEW LATTICE

The purpose of lattice modification is to change the old DB lattice of PLSII to a quadrupole bend lattice, motivat-

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ed by the recent multi-bend lattices, in the most cost-saving way. The method of this paper chooses to add a few magnets to the existing lattice without changing the existing lattice at all.

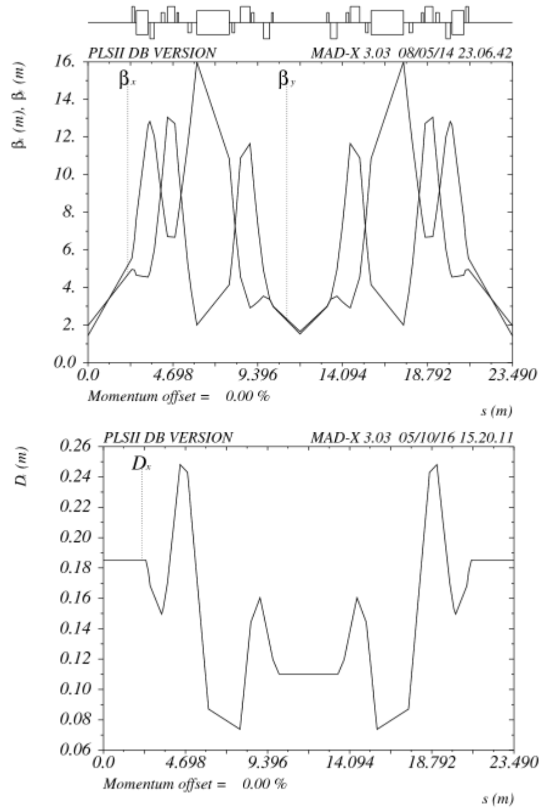

Figure 2: Proposed PLSII lattice.

A proposed new preliminary lattice designed by using the MAD-X code [2] is shown in Fig. 2 and as can be seen in the figure, 1 set of small gradient bending magnets and 1 set of quadrupoles are added into the two ends of each long straight section to turn the DB lattice into a quadrupole bend lattice.

This QB lattice keeps the feature of having two straight sections a cell, but gives better performance. Its electron beam emittance is 2.98 nm rad and the dispersion values at the two straight sections are lower than the present lattice with 0.185 m at LSS and 0.11 m at SSS. After the modification, LSS has the length of 4.88 m which is still long enough to accommodate an injection system.

Regarding cost, the amount of money required by this new lattice is minimal; only 24 small (65 cm length) bending magnets, 24 small (15 cm length) quadrupole magnets and a new vacuum chamber. The existing magnet lattice can just be unmodified at all.

This design in this article is not the final one, but design work will continue for further improvements.

SUMMARY

The upgraded PLSII has achieved the design goals and is operating very smoothly. This articles reports that a small change (adding 1 set of small bending magnets and 1 set of quadrupole magnets into the long straight section) to the present lattice of PLSII can improve the performance significantly through turning it into a quadruple bend lattice.

REFERENCES

[1] T.-Y. Lee, "Status of PLSII Operation", presented at NAPAC'16, Chicago, IL, USA, October 2016, paper "THPOA60", this conference.

[2] W. Herr and F. Schmidt, CERN-AB-2004-027-ABP, 2004.