AN APPLE-II TYPE HELICAL UNDULATOR FOR SSRF

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Abstract

Shanghai Synchrotron Radiation Facility (SSRF) is an intermediate energy (3.5GeV) light source under construction. Specially designed insertion devices will be required to realize the high brightness photon beams made possible by the low emittance of electron beam. The first insertion device being designed is a 4.2m long, 10 cm period, APPLE-II type helical undulator, EPU10.0. This device will use a pure permanent magnetic configuration corresponding to four standard Halbach-type magnet rows which consist of two pairs of planar permanent magnet rows above and below the electron orbit plane. The C-frame support structure is selected. The complete design for EPU10.0, including the magnetic structure, the backing beams, the support structure and the drive systems, is described.

INTRODUCTION

As the third generation of dedicated synchrotron light source, Shanghai Synchrotron Radiation Facility (SSRF) with 3.5GeV energy is scheduled for completion in 2009 [1]. Based on input from the user community, we are designing a set of insertion devices (IDs) and associated beam lines.

Table 1: Main Parameters of the EPU10.0

Magnetic structure	APPLE-II
Period length	100mm
Period number	42
Available gap range	30~85mm
Available phase shift range	-55~+55mm
Speed of gap motion	4mm/s
Speed of phase shift	1mm/s
Peak field for horizontal polarization	0.6 T
Peak field for vertical polarization	0.3 T
Peak field for circular polarization	0.3 T

An elliptically polarizing undulator for the SSRF has been designed and will be under construction recently. The EPU10.0 can generate a linearly (horizontal or vertical plane), an elliptically or a circularly polarized radiation by providing the phase position shifts to the magnet rows of the undulator. The EPU10.0 will produce very bright photon beams in the spectral range of 70eV to 2000eV. The magnetic design is a moveable quadrant pure permanent magnet structure featuring adjustable magnets to correct phase errors and on-axis field integrals. The support structure, backing beam, and positioning system are all designed to function comfortably with a maximum magnetic load of 2,100kg. Main parameters of the EPU10.0 are shown in Table 1.

MAGNETIC STRUCTURE

The four magnetic quadrants [2] [3] [4] are attached to separate backing beams which allow *a* and *d* to translate axially relative to *b* and *c*, which are fixed. The structure of the four magnetic quadrants is shown in Figure 1. Each quadrant has a magnetic structure length of 4.3m, including 42 full magnetic periods, the ends for achieving a gap-independent steering and displacement free entrance and exit, and magnetic trim sections for correction of integrated multipoles.

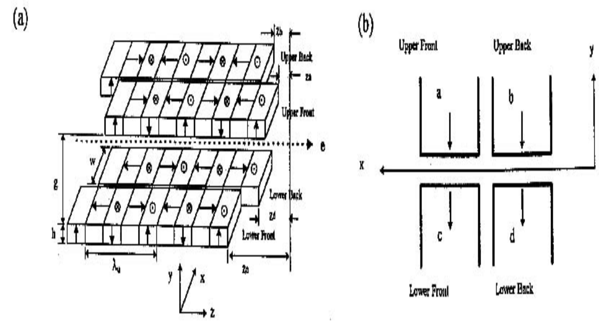

Figure 1: Four quadrants schematic of EPU10.0

Within each quadrant, the basic assembly unit is a 3, 5, or 7 blocks module. Each block within the module is bonded to an aluminium keeper which is mounted to the dove tail connector. Figure 2 shows the scheme of basic module with 5 blocks. Each magnet array consists of 173 blocks of NdFeB including six end blocks. The thickness of the end blocks are designed so as not only to make the first and the second integrals of fields (horizontal and vertical) along the axis of the undulator be zero but also to give no offset of oscillation axis from the axis of the undulator. The same dimensions of the width and the height (35mm × 35mm) of all blocks will give more freedom in the magnet sorting procedure. The magnet holder can be adjusted within ±0.25mm in horizontal and vertical positions by using different thickness shims for the magnetic field tuning. The clearance of 3.7mm between two magnet arrays provides the space for the magnet holder adjustment in horizontal direction.

The magnetic fields were calculated using the analysis formulae for each magnet then linearly superposed for all the magnets. Figure 3 and Figure 4 show the magnet fields on the axis of the undulator and the trajectories of the central electron in the horizontal linear polarization mode and the circular polarization mode with the permanent field of the magnet being 1.2 Tesla and the gap 32mm.

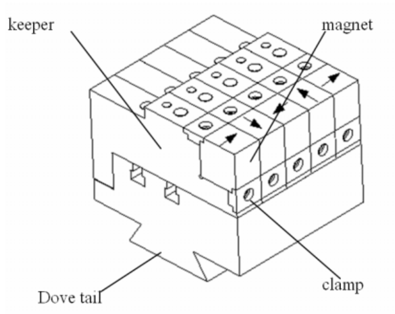

Figure 2: Scheme of basic module

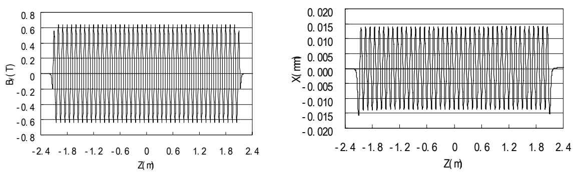

Figure 3: The fields on the axis and the trajectories of the central electron in the horizontal linear polarization mode

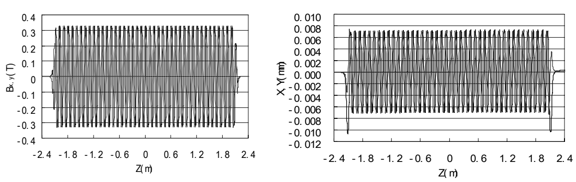

Figure 4: The fields on the axis and the trajectories of the central electron in the circular polarization mode

The magnetic force acting on the magnet arrays varies by phase shifting. It is important to estimate the force when the mechanical design is done. The result shown in Figure 5 indicates that the maximum vertical force (about 2,100kg) occurs when the shift is zero.

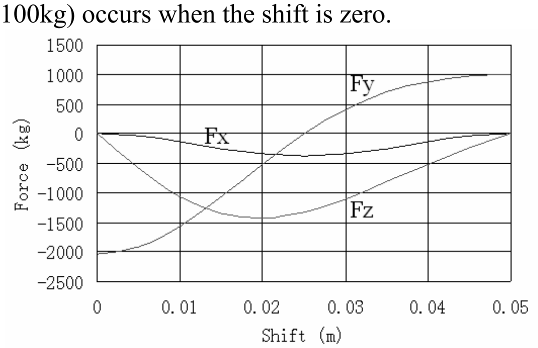

Figure 5: The magnetic force acting on magnet arrays with the gap 31mm

SUPPORT STRUCTURE AND DRIVE SYSTEM

Figure 6, an elevation and side view of the EPU10.0 structure, illustrate the support structure and drive systems. The support structure is a "C" frame design, which is convenient for the magnetic measurements and device installation. The adjusted base with 4 kinematics floor mounts is a welded steel structure, and the adjusted range for y direction is ±6mm, and ±10mm for x, z direction. Two vertical columns with two skew columns to strengthen the rigidity are mounted to the base. Four cube steel tubes, connecting base and vertical columns, further strengthen the stability of the support structure. The vertical columns support four roller screw assemblies which make the vertical moving of the upper and lower beams. The beam is composed of backing beam, stationary beam, and moving beam, which is shown in Figure 7. The backing beam is made of cast-Aluminium, and wrought-Aluminium for stationary, moving beam. The stationary beams support the moving beams via two set of crossed roller slides. The moving beam can move along the two guides mounted between backing beam and stationary backing beam.

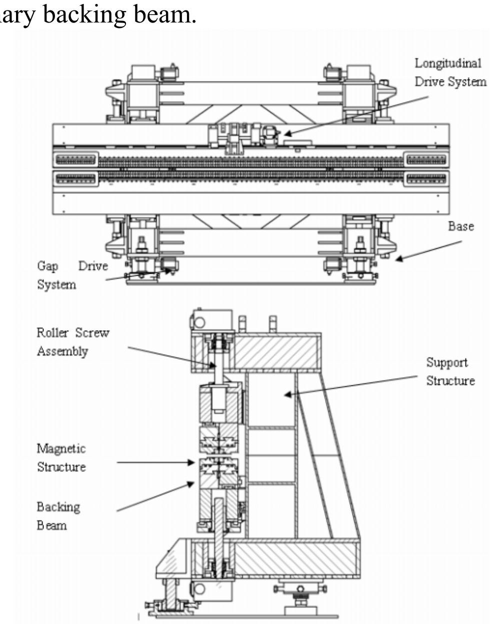

Figure 6: EPU10.0 elevation and side view

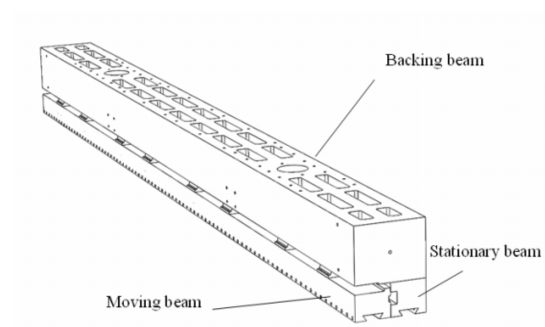

Figure 7: EPU10.0 backing beam

As shown in Figure 8, there are all 6 drive systems controlling the vertical and longitudinal movements. Each drive system consists of a motor, a drive train, an absolute encoder and a controller with digital readout. The vertical gap is moved via each chain drive system connecting a 60:1 worm gear reduction box and servo-motor to one of four roller screw assemblies. Four gratings are mounted to the vertical columns to provide direct feedback to the vertical gap drive system. The longitudinal drive system is a similar system using a smaller roller screw coupled via a 40:1 gear box and servo-motor. There will be two longitudinal drive systems: one for the upper magnetic structure and one for the lower magnetic structure.

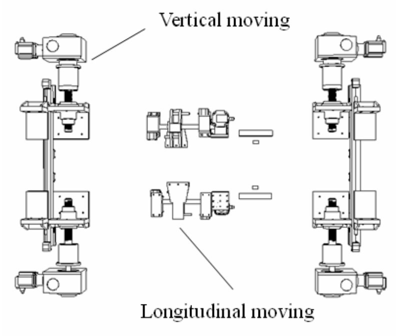

Figure 8: EPU10.0 dive systems

SUMMARY

The design of EPU10.0 for SSRF has been finished. The EPU10.0 will be manufactured recently, and will be completed in August 2008.

REFERENCES

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