THE MAGNETS OF THE VSX LIGHT SOURCE

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Abstract

A third-generation VUV and Soft X-ray synchrotron radiation (SR) ring is being planned to construct at the University of Tokyo. In this paper, the design of the dipole, quadrupole , sextupole and steering magnets for the ring is reviewed. The prototypes of these magnets have been manufactured and its field measurement is now in progress.

1 INTRODUCTION

The University of Tokyo has a future project to construct a VUV and soft X-ray synchrotron radiation facility in a new campus of the university, Kashiwa Campus. The project, VSX project, is composed of two phases. The first phase is to construct a 1.0-GeV racetrack ring which has a circumference of about 230 m and an emittance of about 0.7 nm·rad [1]. A 27 m long undulator installed in the long straight section generates extremely high brilliance SR in the VUV region. The second phase is to construct a 2.0 GeV ring. The ring has a circumference of 388 m, an emittance of about 5 nm·rad and 16 long straight sections. High brilliance SR over a wide wavelength range from VUV to Soft X-ray will be generated by various kinds of insertion devices.

Presented in this paper is a design of the magnets for the ring of the second phase. The magnets for the first phase will be re-designed on bases of the magnets described here.

The ring of the second phase consists of 16 Double Bend Achromat (DBA) cells [2]. Each cell has two long straight sections at both ends for insertion devices. The number of these long straight sections is 16; four of them are 14.3 m long and twelve are 7 m long. The 14.3 m "long" straight sections are arranged with four-fold symmetry. A cell with 7 m "semi-long" straight sections at both ends is called Normal Cell and a cell with "long" straight section at one end is called Long Cell.

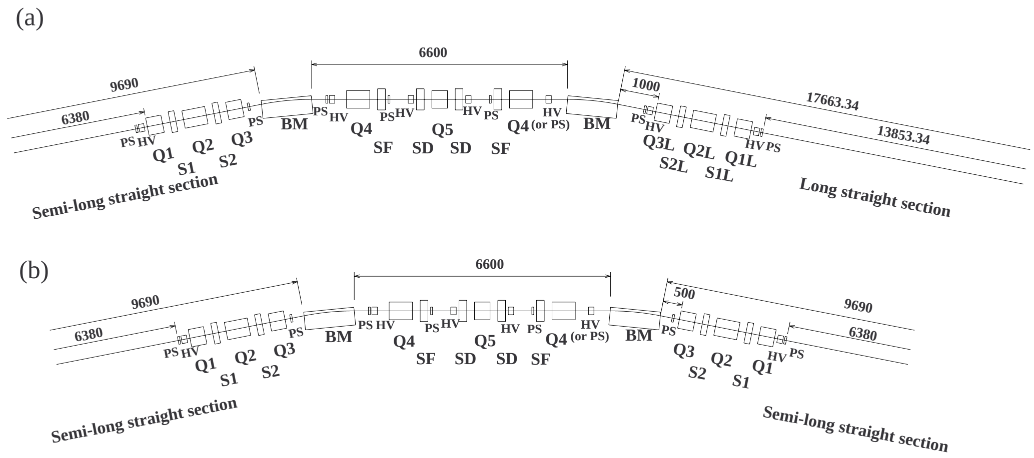

Figure 1: Layout of the ring magnets for (a) Long Cell and (b) Normal Cell.

Figure 1 shows the layout of magnets for Normal Cell and Long Cell. The lattice configuration of Long Cell is the same as that of Normal Cell except for the strength of three quadrupole magnets (Q1L, Q2L, Q3L), two sextupole magnets (S1L, S2L) and drift space between dipole and Q3L. As shown in this figure, the unit cell is composed of two dipoles, nine quadrupoles, eight sextupoles, five to seven DC steerings (HV) and seven to eight fast steerings (FS).

2 MAGNET DESIGN

All ring magnets are optimized for a nominal operation energy of 2.0 GeV, but capable of reaching a maximum energy of 2.5 GeV with good field quality. Table 1 lists the required field quality for the dipole, quadrupole and sextupole. The shape of each magnet has been determined to satisfy these requirements using the two-dimensional program code, LINDA. The magnet cores are made of forged low-carbon solid-steel for the dipole and laminated silicon-steel for the quadrupole and sextupole.

Table 1: Required field quality of the main magnets.

	Dipole	Quadrupole	Sextupole
Maximum field	1.26 T	18 T/m	500 T/m^2
Field uniformity	$\Delta B/B<5\times10^{-4}$	$< 5\times10^{-4}$	$< 5\times10^{-4}$
Good field region	40 mm (H)	30 mm	30 mm

2.1 *Dipole magnet*

Figure 2 shows the cross-sectional view of the dipole magnet. The magnet has a C-type rectangular configuration and bending radius of 6.62 m. The backleg winding is used for adjusting magnet strength individually and also for C.O.D. correction. Figure 3 shows the calculated field uniformity of the dipole magnet for the various field strength.

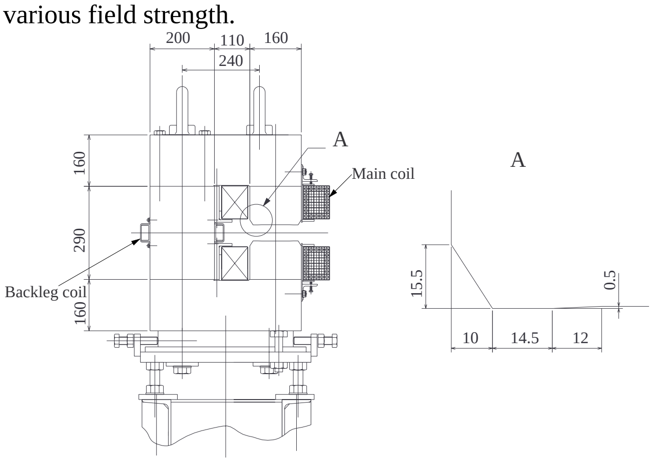

Figure 2: The dipole magnet.

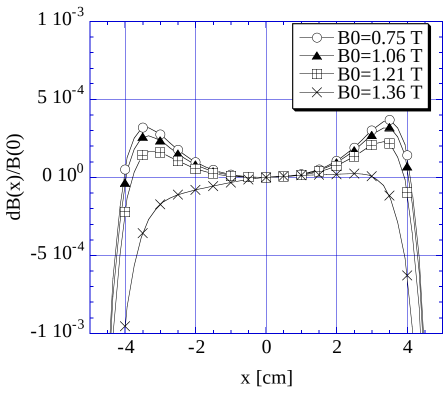

Figure 3: Field uniformity of the dipole.

2.2 *Quadrupole magnet*

There are two types of quadrupole magnet in the ring. One is the "standard type" quadrupole and another is "Collins type" quadrupole. Figure 4 shows a quadrant of cross-sectional view of the standard quadrupole. All of standard quadrupoles have the same cross-sections but there are two different lengths; 0.4 m and 0.6 m. Figure 5 shows the calculated field gradient uniformity of the standard quadrupole. The Collins type quadrupole is adopted to accommodate synchrotron radiation beamline for the Q3 magnet, which is positioned just downstream of the dipole magnet.

An auxiliary coil is wound on every pole of all quadrupoles in order to adjust magnet strength individually and to correct tune shifts due to insertion devices.

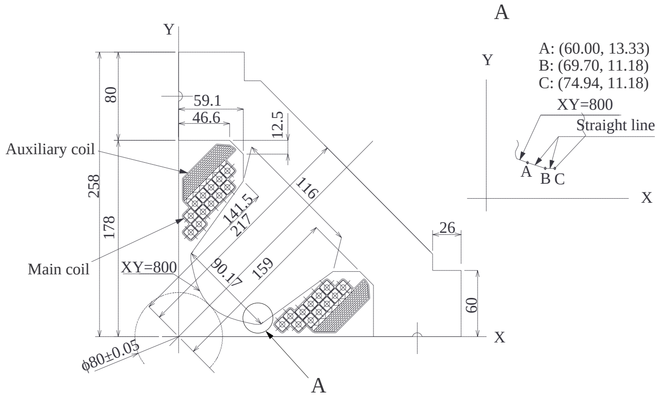

Figure 4: The quadrupole magnet.

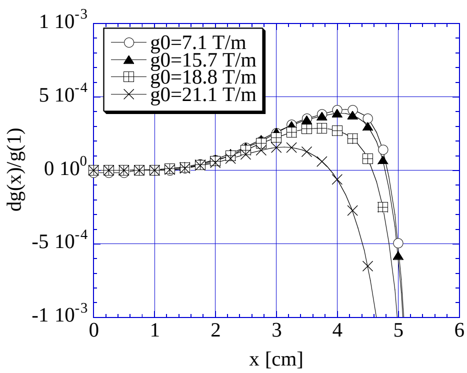

Figure 5: Field gradient uniformity of the quadrupole.

2.3 *Sextupole magnet*

Figure 6 shows the cross-sectional view of the sextupole. All sextupoles have the same cross-section but there are two different lengths; 0.15 m and 0.2 m.

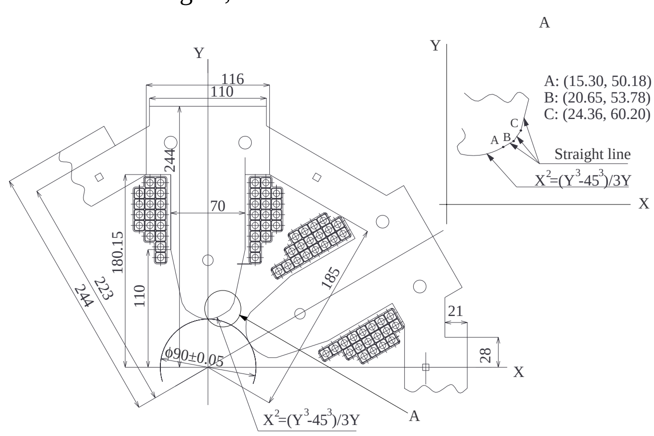

Figure 6: The sextupole magnet.

Figure 7 shows the calculated field gradient uniformity of the sextupole.

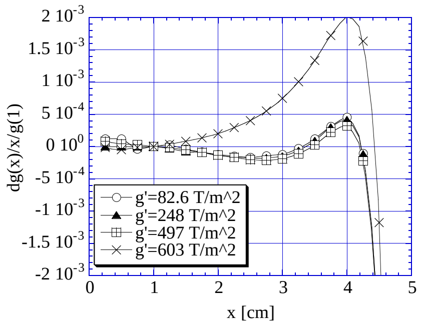

Figure 7: Field gradient uniformity of the sextupole.

The main parameters of the dipole, quadrupoles and sextupoles are summarized in Table 2.

2.4 *Steering magnets*

Main parameters of the steering magnets are listed in Table 3. At least 86 DC steerings and 112 fast steerings are to be installed in the ring for C.O.D. correction and for fast orbit feedback, respectively. The steering has a window frame magnet yoke and can produce both horizontal and vertical fields [3]. The fast steering is expected to operate in a frequency range up to 100 Hz.

Table 2: Main parameters of the magnets.

Magnet	Dipole	Quadrupoles		Sextupoles	
Family		Q1,Q3,Q5,Q1L,Q3L	Q2,Q4,Q2L	SF, SD	S1, S2, S1L. S2L
Number required	32	80	64	64	64
Gap or Bore diameter [mm]	50	80		90	
Core length [m]	1.298	0.4	0.6	0.2	0.15
Max. strength at 2.0 GeV [T, T/m, T/m^2]	1.007	10.9	10.6	389	184
Turn numbers / pole	30	12		18	
Conductor size	16×15-ø9	9.5×9.5-ø5		9×9-ø6	
Max. current at 2.0 GeV [A]	674	585	570	528	249
Max. power dissipation at 2.0 GeV [kW]	9.6	6.1	7.6	9.4	1.8
Auxiliary coil	Backleg	Wound on every pole			
Turn numbers of Auxiliary coil	280 / magnet	100/pole(Q1~Q5), 200/pole(Q1L~Q3L)			

Table 3: Main parameters of DC and fast steerings

	DC steerings		Fast steering	
	Vertical	Horizontal	Vertical	Horizontal
Number of coils	2	2	2	2
Number of turns	1260/coil	720/coil	140/coil	120/coil
Current [A]	5	5	5	5
Magnetic field [G]	400	350	50	120
Core length [m]	0.5	0.5	0.3	0.3
Bend angle [mrad]	0.89	0.6	0.09	0.1

3 PROTOTYPES AND FIELD MEASUREMENTS

Prototypes of the dipole, quadrupole (standard type), sextupole and fast steering have been manufactured at Mitsubishi Electric Corporation and delivered to SRL. The laminated magnets, quadrupole, sextupole and fast steering, are made of 0.5 mm thick silicon steel. They are assembled by gluing without supporting plate on each end. The lengths of the quadrupole and sextupole prototypes are 0.4 and 0.15 m, respectively.

Field measurement of the prototypes is now in progress. Figure 8 shows measured examples for the quadrupole using a harmonic coil method [4]. Detailed results for all prototypes will be reported in near future.

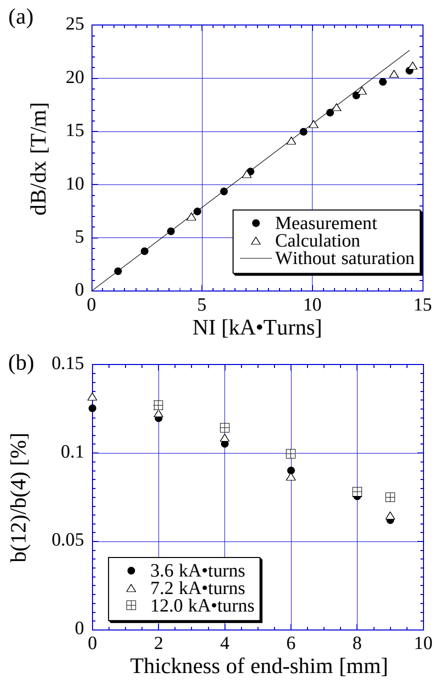

Figure 8: Preliminary results of the field measurement for the quadrupole prototype; (a) excitation curve, (b) relation between thickness of end-shim and normalized dodecapole component at 30 mm from magnet center.

4 REFERENCES

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[2] H. Takaki, T. Koseki, N. Nakamura, Y. Kamiya, Y. Kobayashi and T. Nagatuska ; 'A Lattice for the Future Project of VUV and Soft X-ray High-Brilliant Light Source', to be published in Proc. 1997 Particle Accelerator Conference, 1997.
[3] T. Nagatuska, T. Koseki, Y. Kamiya and Y. Terada : Proc. 1995 Particle Accelerator Conference, 1995, p. 1384.
[4] L. Walckiers; CERN 92-05, p. 138.