

STORAGE RING MAGNET POWER SUPPLY SYSTEM AT THE PLS-II*

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Abstract

Lattice of the Storage Ring (SR) is changed from TDB to DBA, and beam energy is enhanced from 2.5 GeV to 3.0 GeV at the Pohang Light Source upgrade (PLS-II). Therefore all magnet specification and number have to change compare with exist PLS SR. At the PLS-II, Magnet Power Supplies (MPS) must be re-designed according to magnet specification of the PLS-II. Newly development MPSs are adopted switching type power conversion technology. High current unipolar MPSs are parallel operation type of unit module buck type power supply, and low current bipolar MPSs are H-bridge type. All MPSs are performed +/- 10 ppm output current stability and adopted full digital controller. In this paper, we report on the development and characteristics of the MPS for PLS-II SR.

THE PLS-II 1-CELL LINEAR LATTICE

Lattice is DBA structure, and one gradient magnet, four quadrupole and four sextupole are arranged at half section of 1-cell. Quadrupole magnet is consisted of main quadrupole and auxiliary quadrupole, and sextupole magnet is consisted of sextupole, skew, corrector (V/H). The PLS-II SR has 12-cell. Fig. 1 shows 1-cell linear lattice of the PLS-II.

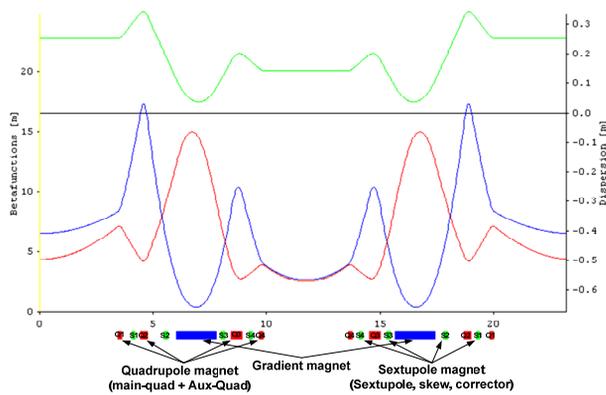


Figure 1: 1-cell linear lattice of the PLS-II SR.

THE PLS-II MPS SPECIFICATION

Unipolar MPS is bending, main-quadrupole, sextupole, septum, bipolar MPS is aux.-quadrupole, skew, slow corrector, fast corrector as bipolar power supply at the PLS-II. These MPSs have to be changed compare with the PLS. Therefore, all power supplies are newly development by using switching power conversion technology and digital controller.

MPS SPECIFICATIONS

Unipolar MPS

Table 1: Main Specifications of unipolar MPS

MPS	MPS [A]max.	Mag. [A]max.	MPS [V]min	24 mag R[mΩ]	24 Mag. L[mH]
Bending	1000	928	508	528.0	696.0
Q1 main	1000	898	384	393.6	52.6
Q2 main	1000	914	483	496.8	81.1
Q3 main	1000	840	588	662.4	127.4
Q4 main	1000	898	384	393.6	52.6
Sext 1	600	456	404	818.4	52.1
Sext 2	600	455	461	945.6	72.0
Sext 3	600	455	461	945.6	72.0
Sext 4	600	455	461	945.6	72.0
MPS	MPS [A]max.	Mag. [A]	MPS [V]min	mag R[mΩ]	
septum	250	230	24	112.9	

Table 1 shows main specifications of unipolar MPS. Bending, main quadrupole and sextupole MPSs are series connected with 24 magnet. Septum MPS is individual connected with magnet. Power conversion of all unipolar MPSs is adopted same switching technology and controlled by digital controller.

Bipolar MPS

Table 2: Main Specifications of Bipolar MPS

MPS	MPS [A]max.	Mag. [A]max.	MPS [V]min	Magnet R[mΩ]	Magnet L[mH]
AQ1	20	13.23	11.2	768.0	23.2
AQ2	20	13.23	14.1	971.0	35.7
AQ3	20	13.23	19.0	1304.0	56.1
AQ4	20	13.23	11.2	768.0	23.2
Skew	20	16.41	7.2	398.0	14.7
HC1	20	14.91	26.1	1589.3	41.3
HC2	20	14.91	31.1	1898.5	57.1
HC3	20	14.91	31.1	1898.5	57.1
HC4	20	14.91	31.1	1898.5	57.1
VC1	20	12.44	21.7	1589.3	75.8
VC2	20	12.44	26.0	1898.5	104.9
VC3	20	12.44	26.0	1898.5	104.9
VC4	20	12.44	26.0	1898.5	104.9
FCH	TBD, total 48 MPS				
FCV	TBD, total 48 MPS				
ID-CH	TBD, total 18 MPS				
ID-VC	TBD, total 18 MPS				

Table 2 shows main specifications of bipolar MPS. All bipolar MPSs are connected with each magnet. Power conversion of all bipolar MPSs is adopted same switching technology and controlled by digital controller.

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THE PLS-II MPS POWER CONVERSION TOPOLOGY

Unipolar MPS

Unipolar MPS of the PLS-II is adopted buck type power converter technology. One-buck converter module has capability 300A/650V. Therefore, bending and main-quadrupole MPSs operate operation as 4-paralleled method, and sextupole MPS operates as 2-paralleled method, and septum MPS operates as single. Controller of the MPS is digital controller. Fig. 2 shows power conversion of bending and main-quadrupole MPS. Fig. 3 shows power conversion of sextupole and septum MPS.

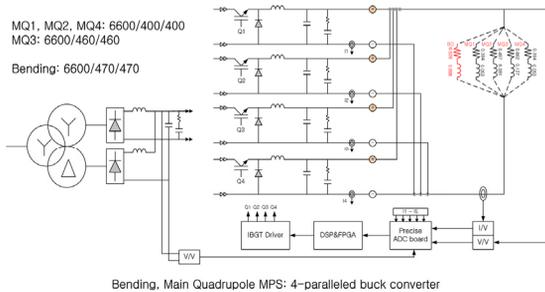


Figure 2: bending and main quadrupole MPSs power conversion.

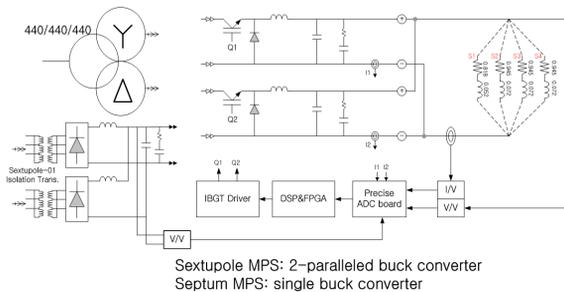


Figure 3: sextupole and septum MPSs power conversion.

Bipolar MPS

Bipolar MPS of the PLS-II is adopted H-bridge type power converter technology. Controller of the MPS is digital controller. Fig. 4 shows power conversion of bipolar MPS.

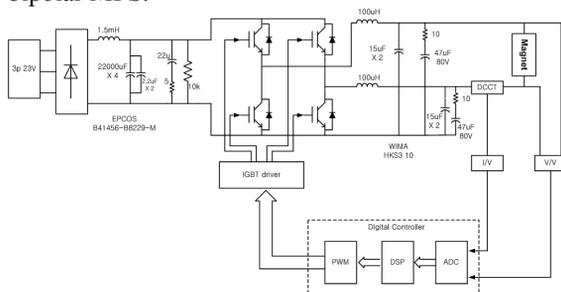


Figure 4: Bipolar MPS power conversion.

MPS DIGITAL CONTROLLER

MPS MPS digital controller is consisted of DSP board, ADC board, DIO board, PWM board and control power board.

DSP board

- Control algorithm: Feed forward PI control.
- Output (TTL): interlock, PWM signal.
- PWM: Max. 8Ch
- PWM Frequency: max. 100 KHz.
- 150MHz Fixed point TMS320F28335 DSP.
- Ethernet (EPICS): Eddy-CPU.
- Fast communication: RS485 (1.25Mbps).

ADC board

- Resolution: >20bits.
- Input Range: $\pm 10V$, $\pm 5V$.
- ADC input port: 3 Ch.

PROTOTYPE MPS FABRICATION AND TEST

Unipolar MPS

Main quadrupole MPS is selected as PLS-II prototype unipolar power supply. Fig. 5 shows prototype unipolar MPS of the PLS-II. Each module is operated by 90 degrees phase shift. Prototype unipolar MPS main specifications are following.

- Input: $3\Phi(Y/\Delta)$, 6600[V]/400[V] 700[KVA]
- Output current: 1000[A]_{max.}, +/-10[ppm]
- Input filter cut-off frequency: 55[Hz]
- 4-paralleled operation of buck converter
- Main DCCT: Danfysik
- Controller: full digital controller
- One module
 - Max. output: 250[A]
 - Switching device: IGBT
 - Switching frequency: 10[kHz]
 - Output filter cut-off frequency: 2[kHz]
 - Aux. CT accuracy: $\leq 0.5\%$



Figure 5: Prototype unipolar MPS.

Prototype unipolar MPS is testing up to now. And all performance test will be test up to May end 2010.

Bipolar MPS

Fig. 6 shows prototype unipolar MPS of the PLS-II. Prototype unipolar MPS main specifications are following.

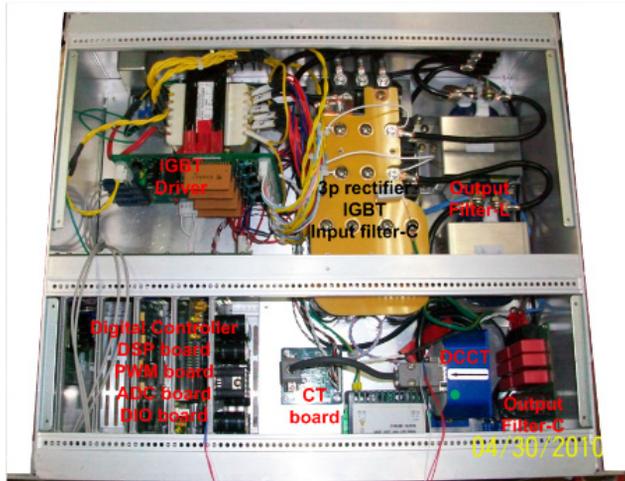


Figure 6: Prototype unipolar MPS.

- Input: 3Φ 23[V]/15[V]/30[V]
- Output current: +/-20[A]_{max.}
- Input filter cut-off frequency: 17[Hz]
- Full bridge converter
- Switching device: IGBT
- Switching frequency: 25[kHz]
- Output filter cut-off frequency: 1.6[kHz]
- DCCT: Danfysik
- Controller: full digital controller
- Ethernet: EPICS IOC
- Option: 1.25Mbps RS485(for fast feedback)

Prototype bipolar MPS is test done all performance. Prototype bipolar MPS data satisfy the PLS-II requirement. Table 3 shows summary test data of prototype bipolar MPS.

Table 3: Summary Test Data of Prototype Bipolar MPS

Item	Value	Remark
Short term stability	+/-2.7ppm	(FWFM) 1 hour
Long term stability	+/-5.3ppm	(FWHM) 17.5 hours
Resolution	5ppm	100uA
Re-productivity	<+/-10ppm	<+/-200uA
Band-width	t _r : < 1ms	
Freq. characteristics(1)	OK	0 ~ 400Hz
Freq. characteristics(2)	OK	0 ~ 50kHz

Fig. 7 shows long term stability data over 12 hours, and fig. 8 shows short term stability data within 1 hour. Fig. 9 shows resolution data.

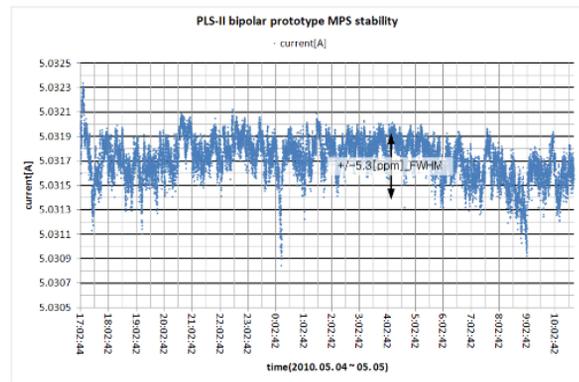


Figure 7: Long term stability

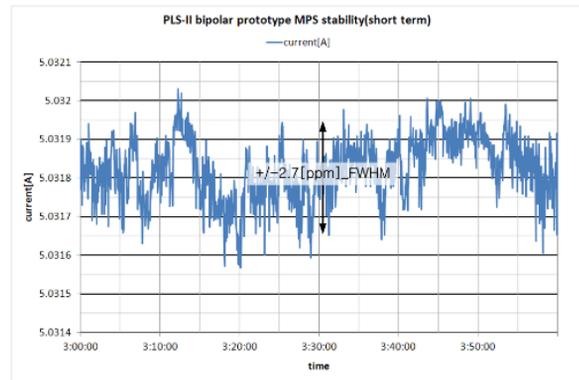


Figure 8: Short term stability.

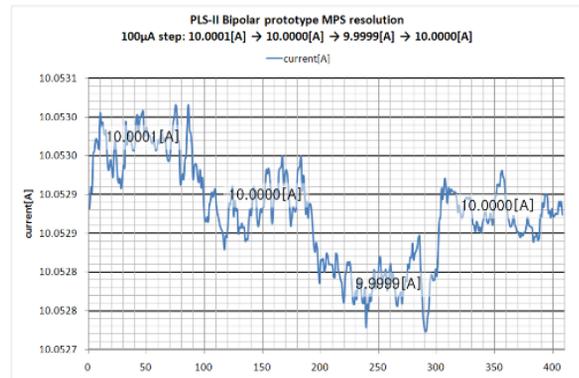


Figure 9: Resolution.

SUMMARY

Unipolar and bipolar MPSs of the PLS-II are developed by using switching type power conversion technology and digital controller. Prototype unipolar MPS is testing up to now. And all performance test will be test up to May end 2010. Prototype bipolar MPS is test done all performance. Prototype bipolar MPS data satisfy the PLS-II requirement as within +/- 10[ppm] stability. All MPS of the PLS-II will be ready until October 2010.

REFERENCES

[1] R. J. Rushton, etc. "Diamond Storage Ring Power Converters", EPAC2006 proceeding, p. 2667 – 26