RECENT ACTIVITY OF PLS STORAGE RING MPS

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Abstract

In the PLS (Pohang Light Source), more than 42 units of uni-polar and 144 units of bi-polar high precision magnet power supplies (MPS's) have been operated since 1994. The uni-polar MPS's are 12-step SCR rectifier type, and the bi-polar MPS's are H-bridge type choppers that adopt IGBT's. Also, 144 units of transistor linear-type shunt controllers for the BBA (Beam-Based Alignment) application were added in 1997. RS422 is used for uni-polar and parallel communication is used for bipolar. Digital interface controller was developed and installed for control the storage ring MPS at 2001. Storage ring uni-polar MPS has operated by using VME EPICS from 2004. For improve the beam stability, we have reduce the ripple and improve the stability of uni-polar MPS. Uni-polar is 16-bit resolution and bipolar is 12-bit resolution. 18-bit resolution bipolar MPS has developed for improving current resolution. In this paper, we have introduce the basic structure of MPS, BBA shunt controller and digital interface controller of storage ring. This paper discusses the results of improving bending MPS performance and measurement results of developed bipolar MPS performance.

PLS STORAGE RING MPS STRUCTURE

43's uni-polar MPS is same structure but it has different output voltage and current. Fig. 1 shows the structure of PLS bending MPS. 6.6 kV input voltage from local electricity supply network is connect with 545V delta winding transformer that has 30 degree phase difference and supply to 12 pulse SCR bridge. Main ripple frequency is 720 Hz. Rectified voltage is filtered by LC and it has supplied the current to magnet. Controller has voltage control loop and current control loop that include L, C filter and load inductance [4].

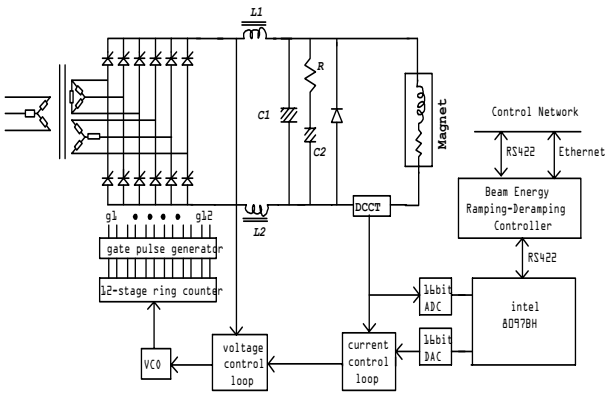

Figure 1: PLS Bending MPS structure

16-bit DAC (AD1147) and 16-bit ADC (ADC72BD) are used for control with high-level computer. PLS is operating at 2.5 GeV full energy injection since Sept 2002. Table 1 shows the capacity and numbers of PLS storage ring MPS. Fig. 2 shows the structure of bipolar MPS. 144 set of bipolar MPS are H-bridge type that using IGBT and switching single pulse type. It was operating parallel communication by using 12-bit DA-AD conversion. Digital interface controller that has serial and Ethernet contact function is developed and installed.

Table 1: PLS Storage ring MPS capacity and numbers

MPS	No	Current	Voltage	Type
Bending	1	850A	643V	Uni-polar
Q1	12	138	84	Uni-polar
Q2	12	138	134	Uni-polar
Q3	12	138	102	Uni-polar
Q4	1	600	327	Uni-polar
Q5	1	600	422	Uni-polar
Q6	1	600	268	Uni-polar
SF	1	200	180	Uni-polar
SD	1	200	180	Uni-polar
Septum	1	250	70	Uni-polar
Skew	4	17	56	Bi-polar
B/trim	4	10	32	Bi-polar
H/Sext	12	16	56	Bi-polar
V/Sext	12	13	56	Bi-polar
H/Corr	70	45	21	Bi-polar
V/Corr	70	110	21	Bi-polar

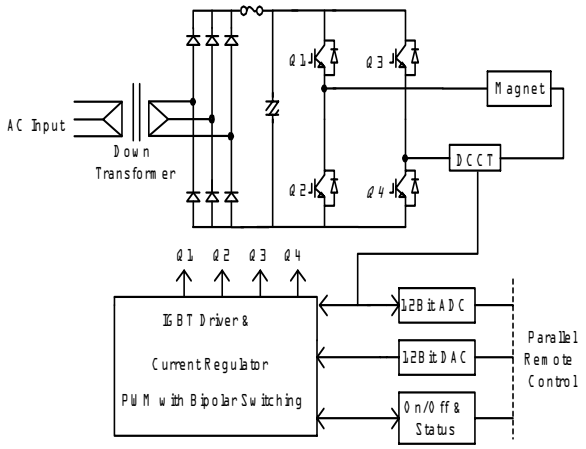

Figure 2: PLS Bipolar MPS structure

TRANSISTOR LINEAR TYPE SHUNT CONTROLLER FOR BBA

Transistor linear type shunt controllers are installed to quadrupole magnet for BBA (Beam Based Alignment) at 1995. BBAPS can control 10% of quadrupole magnet current. [3].

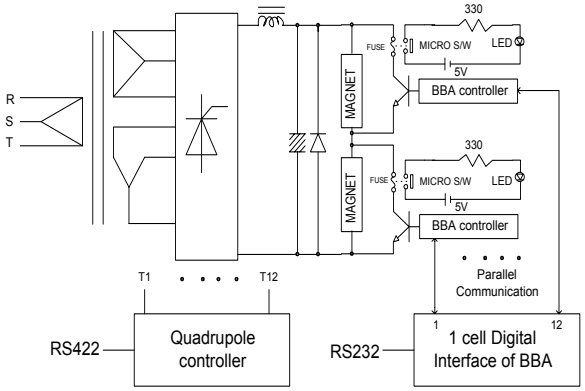

Figure 3: Q1, 2, 3 MPS & BBA PS (Q1, 2, 3)

Fig 3 show the wire connection of quadrupole MPS and BBAPS. PLS storage ring quadrupole magnet wiring is 2-way. Q1, 2, 3 are using one MPS and each 2 magnet is serial connection, Q4, 5, 6 are using one MPS and each 24 magnets is serial connection. These BBAPS is using for beam alignment by using operating beam. Therefore, it should be operate softly. 12 units of BBAPS are installed in 1 cell and it has controlled by 1 digital interface controller that using RS232 communication. Controller is TMS320C32 made by TI Company.

DIGITAL INTERFACE CONTROLLER (DIC) FOR MPS

DIC has been developed and installed for the efficient MPS control. Uni-polar DIC is possible to synchronize control that including bending MPS and Ethernet control at RS422. It operates the storage ring energy ramping and de-ramping [2]. Bipolar DIC is possible to Ethernet control.

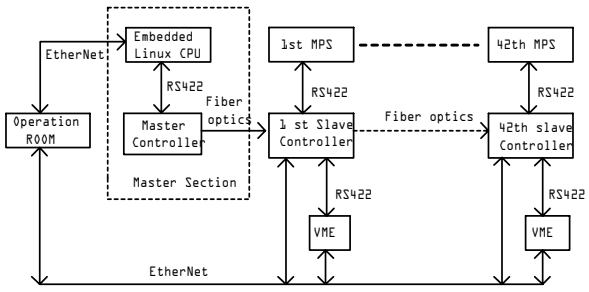

Figure 4: Digital interface controller (Uni-polar)

Fig. 4 shows the functional diagram of uni-polar ramping controller. The master section keeps communicating with control console via TCP/IP. Slave sections are distributed along 42 uni-polar MPS's and series connected through fiber optics. During the ramping and de-ramping operations, MPS's are controlled by the master section of the ramping controller and returns the control to the VME upon completion.

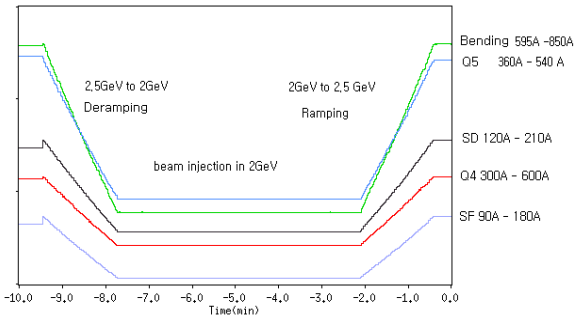

Figure 5: Uni-polar MPS Ramping, De-Ramping Current curve.

Fig 5 shows the uni-polar ramping, de-ramping current curve. Control software is based on EPICS (Experimental Physics & Industrial Control System) using MEDM

RESULT OF BENDING MPS PERFORMANCE IMPROVE

As the efforts for improving uni-polar MPS's, we have changed LC filter structure, optimised the bandwidth of V-I regulator. See Fig. 6 & 7 for BPM signals (short-term orbit stability) before and after the bending MPS LC filter improvement [1].

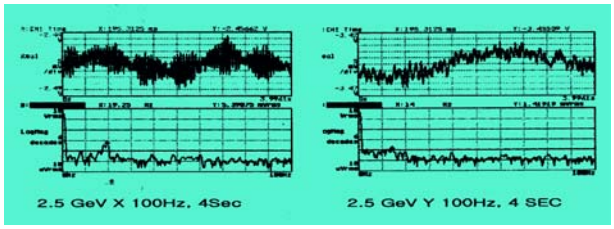

Figure 6: BPM signal before Bending MPS LC Filter change

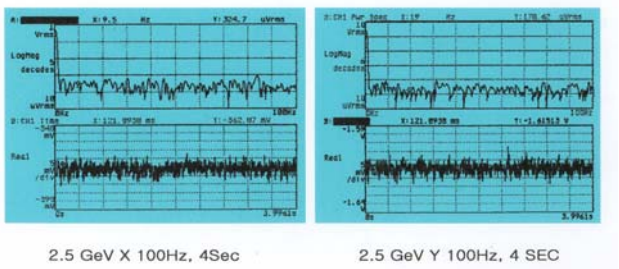

Figure 7: BPM signal after Bending MPS LC Filter change

16BIT, 18BIT CORRECTOR MPS DEVELOPMENT

For orbit correction and feedback control, corrector MPS require high current resolution. We have been developing the 16bit, 18bit Corrector MPS.

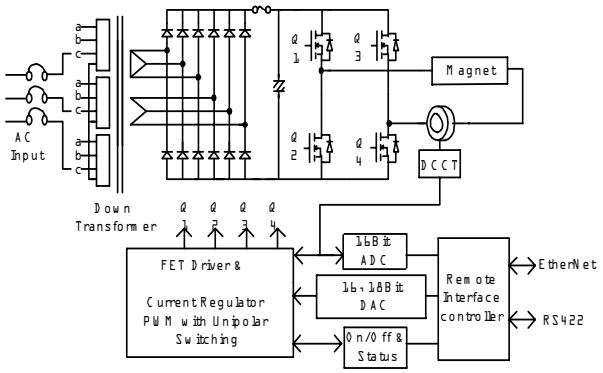

Figure 8: Structure of developed corrector MPS
3 phase transformer 208/13.7Volt*2(Y, Δ)
3 phase diode: FUJI 6RI100E-060(100A 600V)*2
Aluminum capacitor: 47000μF 50V*4
FET: SEMIKRON SKM313B010 (400A 100V)*2
FET driver: CONCEPT 2SD315AI*2
DC link voltage: 17.8Volt
FET switching frequency: 50kHz
Output voltage switching frequency: 100kHz
Load (Magnet): 16mH, 53mΩ
Load current max: ± 110A

Fig 8 shows the developed corrector MPS structure. DAC is 16-bit, 18bit and ADC is 16-bit and switching frequency is 100kHz.

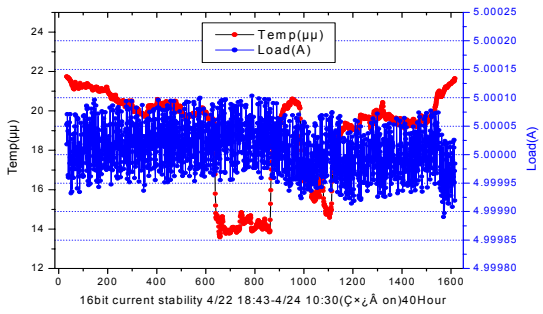

Figure 9: New corrector MPS output current stability (+6.5A: max-15A)

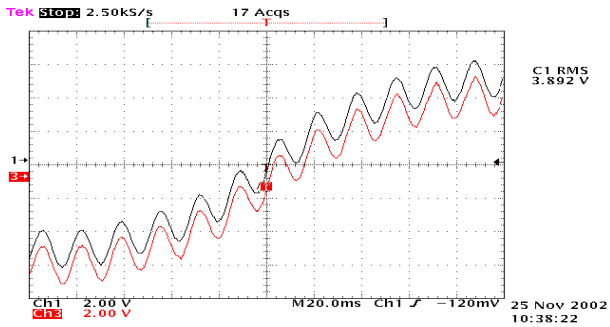

Figure 10: New corrector MPS ± ac+dc operation
CH1 Ref black: (16.667A/10V)
CH3 Load red: (16.667A/10

Fig 9 shows the new corrector MPS output current stability. It shows the current stability that maintain the ±10ppm during 40 hour when environment temperature change 9 °C. Figure 10 shows the AC+DC current operation without crossover distortion.

CONCLUTION

From the research and development, SCR rectifier type unipolar MPS has achieved ± 15ppm current stability and FET H-bridge chopper type bipolar MPS has achieved ± 10ppm current stability and 18bit current resolution performance. Base on these result, we have response to upgrade magnet power supply performance and develop the high performance power supply.

REFERENCES

[1] Jae-Hag SEO, Sang-Hun NAM, Eun-San KIM and Sung-Ju PARK. "Effect of Bending-Magnet Power Supply Ripple on the Beam Performance in the Pohang Light Source" JKPS, Vol. 43, No. 2, August 2003, pp. 227 - 231

[2] Eun-San Kim, Ki-Man Ha, Jae-Hag Suh and S.H. Nam "Energy Ramping System in PLS Storage Ring" EPAC2002, Paris, France (June 3-7)

[3] S. H. Nam, J. H. Suh, K. M. Ha, J.Y. Hung, and I. S. Ko "HIGH CURRENT SHUNT REGULATOR FOR QUADRUPOLE MAGNETS IN PLS 2GeV STORAGE RING," 1997 PAC

[4] B. H. Kwon, E. H. Song "Design of Current Source Using 12-pulse Phase-Controlled Rectifier," IEE PROCEEDINGS-B, Vol. 138, No. 4, JULY 1991