CONTROL SYSTEM OF TWO SUPERCONDUCTING WIGGLERS AND CONPENSATION MAGNETS IN THE SAGA LIGHT SOURCE

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Abstract

The SAGA Light Source (SAGA-LS) is a synchrotron radiation facility. Three insertion devices: a 4 T superconducting wiggler, an APPLE-II undulator, and a planar undulator, are used for synchrotron radiation experiments. For the further demand of hard x-ray experiments, we are investigating to install a second superconducting wiggler. To compensate strong tune shift caused by the superconducting wiggler, a part of the quadrupole magnets families will be excited by independent power supplies. We developed the control system of the storage ring power supplies for the superconducting wiggler. The PLC used for control of the new quadruple magnets power supplies are linked by optical fiber cable to synchronize each main power supplies in the storage ring. We tested the synchronicity of the PLC sub unit for the new quadrupole magnets in the test bench.

SAGA LIGHT SOURCE

SAGA-LS is a synchrotron radiation facility consisting of a 255 MeV injector and a 1.4 GeV storage ring [1]. The electrons from the linac are injected into the storage ring, and ramped up to 1.4 GeV in 4 minutes. The user mode operation for synchrotron radiation experiments with a stored current of 100 mA has been performed since 2006 [2], and the further developments of the accelerator have been made [3]. To meet the needs of the hard x-ray experiments a 4 T superconducting wiggler was installed in 2010 [4,5]. We perform the accelerator operation at the maximum stored current of 300 mA at this stage. Fig. 1 shows the layout of the accelerator complex of the SAGA-LS and beam lines. For the further requirements of the hard x-ray experiments, we began to investigate a second 4 T superconducting wiggler. The control system of the second superconducting wiggler and compensation magnets power supplies system are developed.

CONFIGURATION OF THE POWER SUPPLIES

The configuration of the quadrupole magnet family (QF1 Family) is shown in Fig.2. To correct of the strong tune shift (Horizontal: -0.031, Vertical: 0.068 measurement result [5]) caused by the superconducting wiggler, a part of the quadrupole magnets are excited by the independent power supplies. The lattice of the SAGA-LS storage ring is 8 symmetry Double Bend type, and there are 3 quadrupole families (QF1, QD1, and QF2 families). A pair of quadrupole doublet (QF1 and QD1) is used for the tune correction. The new quadruple magnets power supplies for the tune correction must work simultaneously to the main power supplies of the storage ring magnets during the ramp up period, because the new quadrupole power supplies constitute a part of the main quadrupole magnets families of the storage ring.

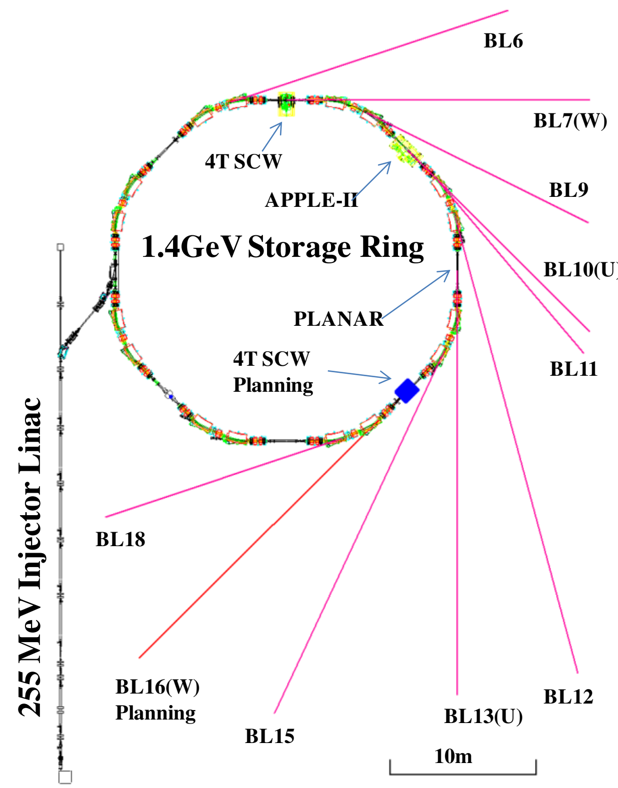

Figure 1: Layout of the SAGA Light Source.

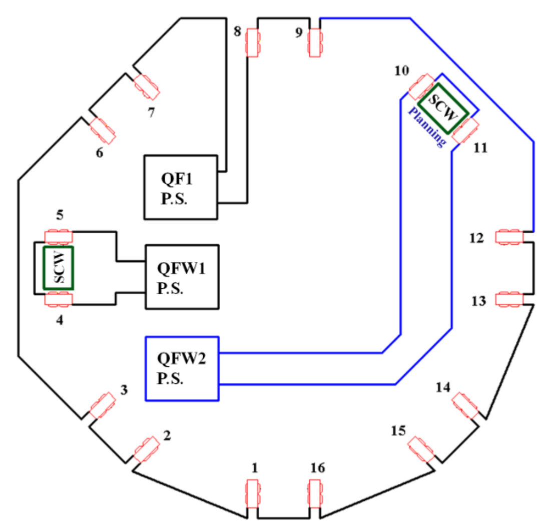

Figure 2: Configuration of QF1 Power Supplies Family. The blue lines indicate modifying section.

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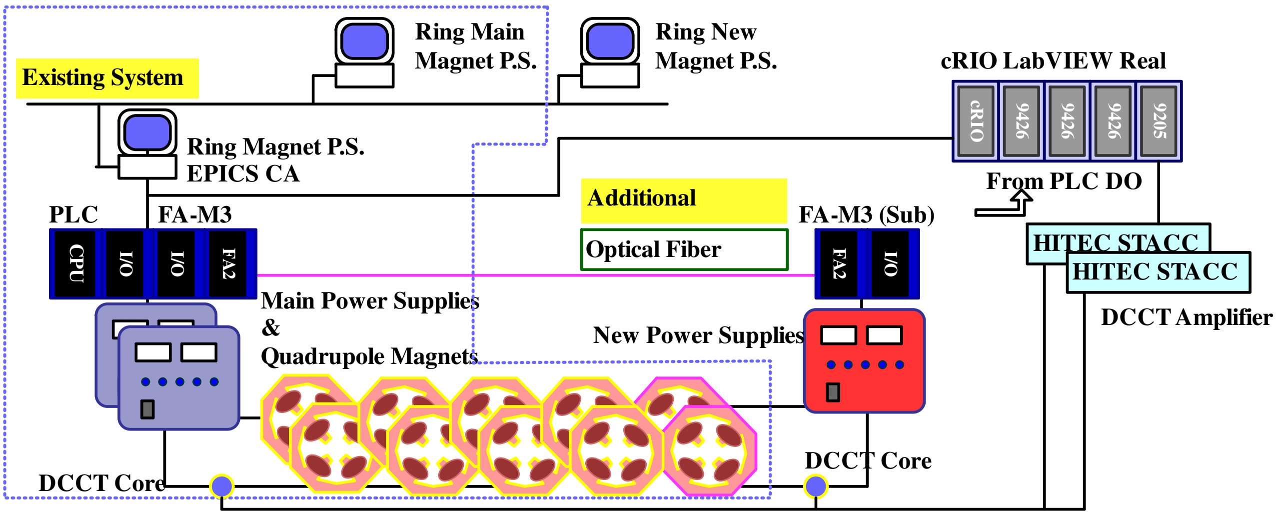

Figure 3: Existing power supplies control system and developing power supplies control system. Sub unit of the PLC is connected by the optical fiber cable to main PLC unit to synchronize to main PLC unit. The external DCCT of the power supplies are also shown. The external DCCT are used for feed-back current control system and accurate monitoring of the power supplies.

CONTROL SYSTEM

Superconducting wiggler

The 3 pole hybrid type superconducting wiggler [4,5] is demagnetized in the injection time, and raised to 4 T after ramp up. The excitation pattern files of the power supplies of the superconducting wiggler are stored in the PLC file memory. The pattern files of the side pole magnets were determined to minimize the closed orbit distortion. The control system of the second superconducting wiggler will be constructed same configuration to the existing 4 T superconducting wiggler.

Quadrupole Magnets

The quadrupole magnets and another power supplies are excited for injection to the storage ring. After the injection the power supplies are excited up to 1.4 GeV in 4 minutes. During the ramp up period, 10000 set points of the power supplies are outputted from the file memory of the PLC. The strobe signal for the set point of the power supplies are outputted in every 10 msec (the width of the strobe signal is 2 msec). The new quadrupole power supplies for the superconducting wiggler must work simultaneously to the main power supplies and used for correction of the strong tune shift caused by the superconducting wiggler. The requirement to the control system of the new quadrupole power supplies are synchronicity to the main power supplies and independent output current control. The PLC for the new quadrupole magnet power supplies are connected to the PLC unit by the optical fiber cable to constitute the sub unit of the main PLC as shown in Fig. 3. The pattern file of the new quadrupole magnet power supplies for the ramp up is included in the main PLC file memory.

A PC server are used to control PLC and EPICS server [6,7]. Each client PC in the control room can communicate to the server PC by the EPICS Channel Access (ActiveXCA). PC based control system have been developed on National Instruments LabVIEW. Remote desktop service of The MS Windows is also used.

External DCCT Feed-back System

The output currents of the main power supplies in the storage ring are measured by external DCCT (HITEC STACC) for the accurate monitoring. Slow (1 Hz) feed-back the current control by external DCCT and National Instruments Field Point FP1601 AI110 (16 bit ADC) have been performed in the existing system (See Fig. 4).The same specification of the external DCCT for the new quadrupole magnet power supplies are prepared.

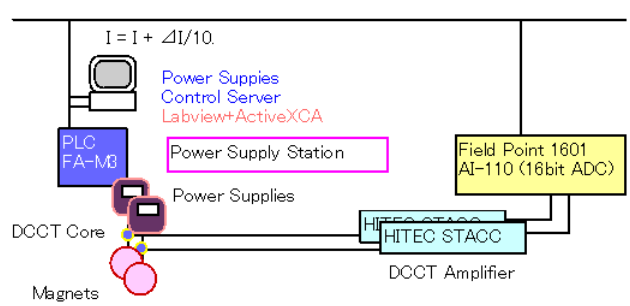

Figure 4: Feed-back Current Control System by External DCCT.

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Chromaticity and Coupling Correction

The excitation of the superconducting wiggler causes chromaticity and betatron coupling modulation. To correct the aberrations, 12 pole multipole magnets are installed in vacant long straight section. The magnetic strength of the sextupole and skew quadrupole are 40.04 T/m^2 and 1.71 T/m respectively. The performance of the multipole magnets for the correction was examined with the existing superconducting wiggler. The power supplies of the mutipole magnets equip independent PLC CPU, and directly controlled through Ethernet LAN.

TEST BENCH

We constructed the test bench of the PLC (YOKOGAWA CPU: SP76-7S × 1, I/O:WD64-3P × 5, FA Bus: LR02-02× 2) to confirm the synchronicity of the PLC sub unit. The ladder program of the PLC of the magnet power supplies was modified so as to be adopted with the I/O configuration of the test bench of the PLC. Fig. 5 shows the strobe signals from the Bending magnet power supply, QF1 power supply, and QFW2 (sub module) power supply measured by the YOKOGAWA Logic Analyzer [8]. As shown in Fig. 5, these signals are synchronized within 1 msec.

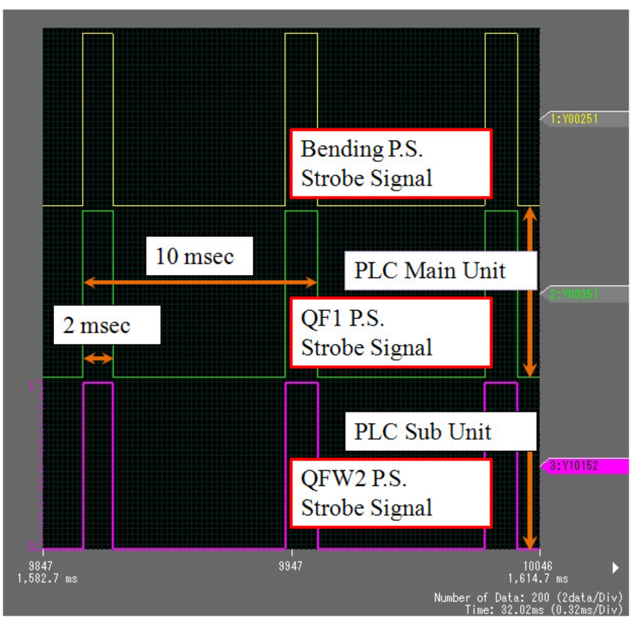

Figure 5: The trobe signals of bending magnet P.S., QF1 P.S., and QFW2 P.S. during the ramp up time.

CONCLUSION

To install the second superconducting wiggler, a part of the quadrupole magnet power supplies will be replaced by the independent power supplies. The power supplies of the quadrupole magnets families in the storage ring must work simultaneously during the ramp up period. We developed the control system of the storage ring power supplies for the second superconducting wiggler. The strobe signals for the ramp up from the PLC sub unit linked by the optical fiber cable were synchronized within 1 msec to the main unit. The 12 pole magnets will be used for the chromaticity and coupling correction.

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