PRESENT STATUS OF THE SAGA-LS CONTROL SYSTEM

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Abstract

The SAGA Light Source (SAGA-LS) is a synchrotron radiation facility consisting of a 255 MeV injector linac and a 1.4 GeV storage ring with a circumference of 75.6 m. Since it first became available to users in 2006, the SAGA-LS has been stably providing synchrotron light over a wide spectral range. A simple PC-LabView based system, which uses EPICS channel access (ActiveX CA) as a communication protocol, is utilized to control the SAGA-LS accelerator complex. The system consists of commercial IO devices connected to local server PCs (CA servers), console PCs (CA clients), and Ethernet LAN. Both the server and client applications are developed in LabView to simplify software modification and development in conjunction with machine improvements. The SAGA-LS control system has been extended in response to the machine improvements made over the past few years.

OVERVIEW OF THE SAGA-LS FACILITY

The SAGA Light Source (SAGA-LS) [1, 2] is a synchrotron radiation facility constructed and operated by the Saga Prefectural Government in Japan. The SAGA-LS facility has been stably providing synchrotron light over a wide spectral range from VUV to hard x-rays since user operation started in February 2006. The SAGA-LS accelerator complex consists of a 255 MeV injector linac and a 1.4 GeV storage ring with a circumference of 75.6 m. The current layout of the facility is shown in Fig. 1 and the main parameters of the injector linac and storage ring are summarized in Table 1.

Along with user operation, machine improvements have been performed over the past three years [3]. A septum magnet has been replaced, the control system for the injector linac has been upgraded, and a beam diagnostic system [4] has been constructed. In addition, insertion devices have been developed and installed. The SAGA-LS storage ring is currently equipped with two insertion devices: an APPLE-II type [5] variable polarization undulator and a planar undulator (Saga University).

To meet users requirements for high-energy hard x-rays, we have been developing a 4 T class superconducting wiggler [6], which is scheduled to be installed in 2010. In addition, we have constructed an experimental setup for generating MeV photons by laser Compton scattering for beam energy monitoring and future user experiments.

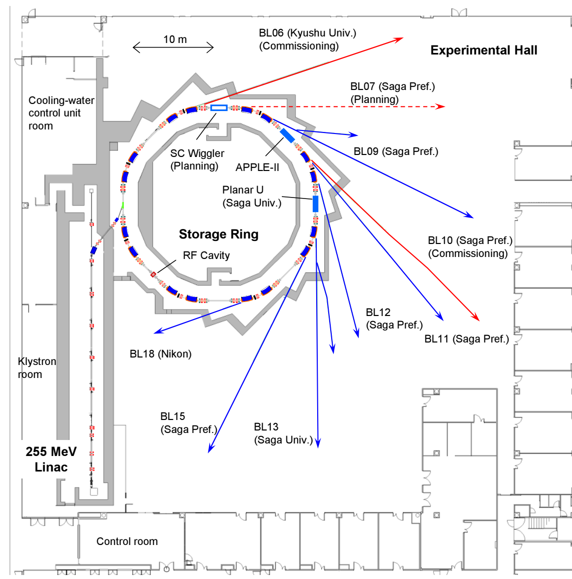

Figure 1: Layout of the SAGA-LS facility as of September 2009. There are six operational beamlines and two more are being commissioned.

Table 1: Main Parameters of the Injector Linac and Storage Ring

Injector Linac	
Energy	255 MeV
Repetition rate	1 Hz
RF frequency	2856 MHz
Macropulse width	200 ns
Macropulse charge	12 nC
Storage Ring	
Maximum energy	1.4 GeV
Circumference	75.6 m
Natural emittance	25.1 nm·rad
RF frequency	499.8688 MHz
Harmonic number	126
Betatron tunes (H/V)	5.796/1.825
Energy spread	6.7×10^{-4}
Momentum compaction	0.013
Filling beam current	300 mA

CONTROL SYSTEM

System Outline

A simple PC-LabView based system, which uses the EPICS channel access (ActiveX CA) [7] as a communi-

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cation protocol, is utilized to control the SAGA-LS accelerators. The SAGA-LS control system has already been described in detail in previous reports [8, 9]. This PC-LabView based control system was designed to be cost-effective, easy to maintain and upgrade, and have a high reliability [10].

Figure 2 shows the configuration of the SAGA-LS control system. The system consists of I/O devices connected to local server PCs (CA servers), console PCs (CA clients), and an Ethernet LAN. The local server PCs connected to the I/O devices are used as input/output controllers (PC-IOCs). To ensure cost effectiveness and high reliability, we employed commercial I/O devices such as FieldPoint (National Instrument) and PLC FA-M3 (Yokogawa). Server and client applications are developed in LabView since the LabView environment makes it easy to upgrade and develop the software in-house. About 2,000 process variables have been employed to control accelerator components such as magnet power supplies, RF systems, vacuum monitors, beam diagnostic systems, and insertion devices. The communication rate is typically 2–10 Hz using Windows 2000 PCs with 2.66 GHz Intel Pentium 4 processors. This PC-LabView based control system has been running without serious problems since the commissioning phase of the SAGA-LS facility.

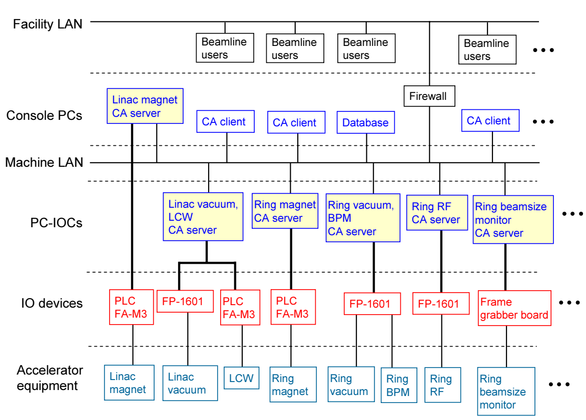

Figure 2: Schematic drawing of the SAGA-LS control system. EPICS channel access (ActiveX CA) is used as the communication protocol for the client-server system.

Database

Since the ActiveX CA does not support a database function, we utilized a stand-alone database system. MySQL was selected as the database system for the SAGA-LS facility. Database tools (e.g., displaying trends of archived data) are LabView applications, while a data logger was developed in Delphi. Currently, about 700 process variables are logged every 1 min and about 4 GByte of data is archived per year.

RECENT DEVELOPMENTS

To enhance the accelerator performance, machine improvements have continued over the past few years. The SAGA-LS control system has been extended as a result of these machine improvements. The following sections describe recent extensions to the control system.

Injector Linac

The injector control system was upgraded from a manual control system to a computer-based system. This new system allows a reliable operation and tuning of the injector linac. Figure 3 shows a PC display of the new injector control system. This new system is used to control the klystron modulator, the electron gun, and the RF system of the injector linac. In addition to upgrading the control system, we have developed a client application to automate the various control sequences in beam injection. We confirmed that the new system can be used to automate most of the control sequences.

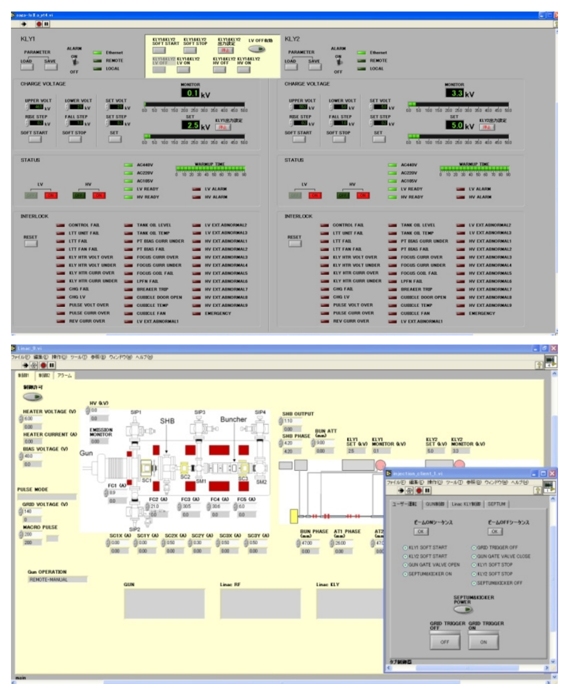

Figure 3: Control panels for the injector linac.

Beam Diagnostic

We have constructed two synchrotron radiation (SR) monitor beamlines, BL20 and BL21, for beam diagnostics. In BL20, a SR interferometer [11] was constructed to measure both the horizontal and vertical beamsizes. The SR interferogram data, which provide beamsize data, are acquired on a server PC using a frame-grabber board. The beamsize data is routinely obtained every 1 s through a client-server system. The beamsize data are used for precise lattice tuning and for controlling betatron coupling.

Details of the beamsize measurement system are described in Ref. [4].

Insertion Device

An APPLE-II undulator was installed in 2008 as shown in Fig. 4. After its installation, we studied the effect of changes in the pole gap and phase of the undulator on the electron beam. Based on these measurements, we constructed a feedforward correction system to minimize the effects of the undulator on the electron beam. It was necessary to develop the correction system to enable insertion devices to be fully controlled by beamline users. The correction system successfully compensates for closed orbit distortion (COD), betatron tune shift and a small change in the betatron coupling. For instance, the standard deviation of the COD variation relative to the reference orbit is suppressed to less than 4 μm when the the pole gap and phase are changed [12].

The small change in the betatron coupling is compensated using a wire skew quadrupole magnet, which is similar to the flat wires used in BESSY-II for multiple compensation [13]. The wires are mounted on the upper and lower surfaces of the undulator duct as shown in Fig. 4. Feedfoward coupling correction is applied to the horizontal polarization operation of the APPLE-II undulator, reducing the effect to a relative change in the vertical beamsize of 5%. This feedfoward system is also applied to the planar undulator of Saga University. The feedforward system enables beamline users to independently control the pole gap during the horizontal polarization operation of the APPLE-II undulator and during operation of the planar undulator.

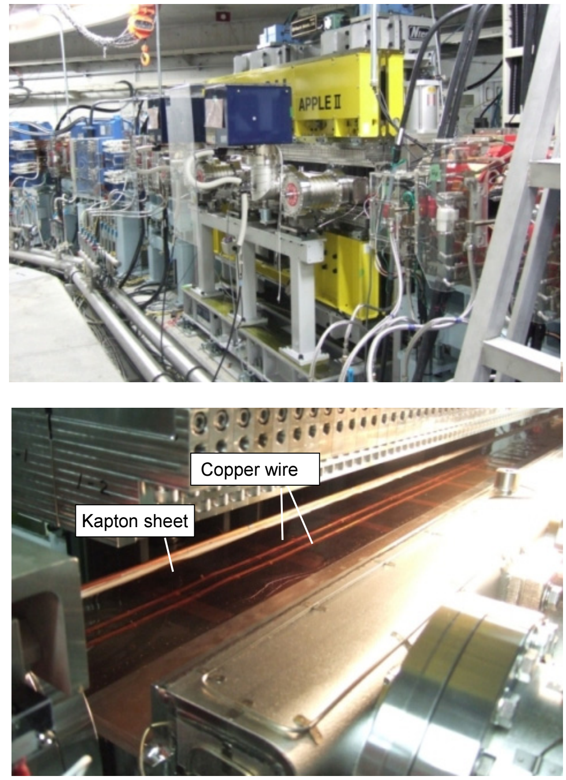

Figure 4: (Top) Photograph of the APPLE-II undulator installed in 2008. (Bottom) Wire skew quadrupole magnet mounted on the undulator duct.

SUMMARY

The SAGA-LS has been stably operated by means of a PC-LabView based control system. This control system has been running without serious problems since the commissioning phase of the facility. To enhance the performance of the accelerator, machine improvements have been performed, including upgrading the injector control system, constructing a beam diagnostic system, and installing insertion devices. In conjunction with these improvements, we have extended the client-server system using ActiveX CA as a communication protocol. All of these new systems were developed in house and have been used during user operation at the SAGA-LS facility.

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