

## SAGA-LS CONTROL SYSTEM USING LABVIEW-ACTIVEX CA

H. Ohgaki<sup>#</sup>, Institute of Advanced Energy, Kyoto University, Kyoto, 611-0011, Japan  
 Y. Iwasaki, S. Koda, Y. Takabayashi, K. Yoshida, T. Tomimasu, SAGA Light Source,  
 Tosu, 841-0002, Japan

H. Toyokawa, National Institute of Advanced Industrial Science and Technology,  
 Umezono 1-1, Tsukuba, Ibaraki 305-8568, Japan

### Abstract

The control system of SAGA Light Source (SAGA-LS) has been constructed. The system consists of off-the-shelf IO devices, FieldPoint (National Instrument), and PLCs, FA-M3 (Yokogawa), directly connected to the local server PCs (PC-IOCs) and remote client PCs. The communication protocol between server and client is the simple Channel Access protocol emulated by ActiveX CA. The applications are developed by LabView. About 1,500 process variables are employed to control about 500 control objects, such as the magnet power supplies, the RF control, vacuum monitors, BPM data, and LCW data. The system has been operated and tuned from the beginning of the commissioning, July 2004. At present stage, we are satisfied with the system performance with the communication rate of 2-5 Hz. MySQL database system also archives data to assist daily operation and to display the historical trend of the machine. The database applications also developed using LabView. Toward the normal operation for beam-line users, October 2005, we will brush-up the system.

### INTRODUCTION

The SAGA synchrotron light source (SAGA-LS) is a medium size third-generation light-source, which is constructed by a local Japanese government[1]. The construction of the facility building started in fall of 2002 in Tosu, Saga Prefecture. The installation of the injector linac and the storage ring started in fall of 2003. The commissioning has been carried out from summer of 2004. We succeed in acceleration with linac at August 30, 2004 and also achieved the first storage in the storage ring at November 12, 2004.

A critical issue on this facility is its tightly restricted budget and, hence, limited number of staff. Consequently the control system for SAGA-LS should be simple and robust, while inexpensive, easy to develop, maintain and expandable. The use of the off-the-shelf products and PC brings us the only solution to this issue. The PC control system is commonly used in many facilities[2] because of a very high cost performance of PC. On the other hand, there are sophisticated and well-established control systems based on workstations, such as EPICS, which have been used in many large accelerator facilities. Since EPICS system runs on a PC-UNIX system, a UNIX PC-

based EPICS system is one of a typical control system. However, it is difficult to implement and expand the EPICS system without EPICS expert. Fortunately, the number of the control object of the SAGA-LS is about 500 and there are very few demands for real-time control, at least during the commissioning. So, we designed a Windows PC-based control system which only uses the EPICS channel access (CA)[3]. There are many excellent works to develop CA components for the PC-Windows environment[4]. ActiveX CA[5] is one of such component. Although the ActiveX CA is not fully functioned EPICS, a PC with the ActiveX CA server and off-the-shelf IO devices works as an IO controller (PC-IOC)[6]. Because the data communication protocol is subset of the EPICS CA, we can use the existing diagnostic tools which use the CA. Moreover, the system can be upgraded to the standard EPICS system seamlessly, if higher performance and/or real-time processing will be required.

LabView is one of the easiest environment for software development and a familiar tool for beam-line users. As we need daily update of the control application during the commissioning, the in-house modification is crucial issue rather than the performance one. So LabView-ActiveX CA is most promising system for SAGA-LS. In this paper, we will describe the system outline of the present system.

### SYSTEM OUTLINE

SAGA-LS control system consists of PC-IOCs directly connected to the off-the-shelf IO devices, console PCs, and control LAN. Fig.1 displays the schematic drawing of the system. As is shown in figure, the system can be

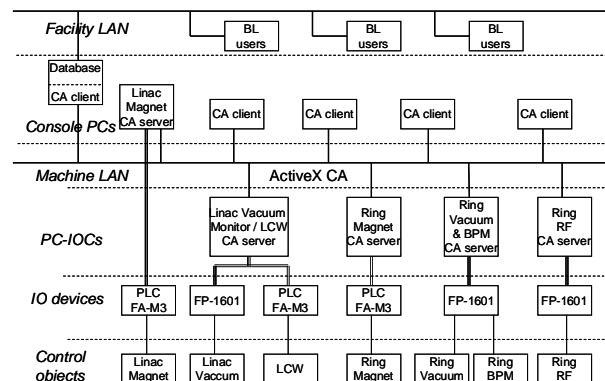


Figure 1: Schematic view of the SAGA-LS control system.

<sup>#</sup>ohgaki@iae.kyoto-u.ac.jp

separated to be six interface-layers of hierarchy in detail. From top to bottom, the layer corresponds to the facility LAN layer, operator interface layer, machine LAN layer, device interface layer, IO device layer, and control object layer. At present stage, the control objects are 1) magnet power supplies, 2) vacuum monitors, 3) beam position monitors in the storage ring, 4) ring RF system, and 5) the low conductivity water. Total number of the control object is more than 500 at present stage. This number will increase in the normal operation. Following section we will describe the detail of the present system.

### PC-IOC

A PC with slot IO cards is the most cost effective IO device and this configuration works as a stand alone PC-IOC[7]. However, there are several problems on this configuration. First, reliability of the slot IO card is not high. Second, the system operator has to catch up the version update of the OS and the hardware drivers. Besides he may have to rewrite the control applications in some cases. So, we chose the industrial IO device which is reliable, off-the-shelf one, and stand-alone. Generally the product lifetime of the industrial IO device is longer than that of the slot IO card. Recent industrial IO devices have their Ethernet modules and work as IOC. However, we put PCs between the machine LAN and the IO device 1) to convert the IO device parameter into the physical one, 2) to hide the IO devices from the LAN to secure the control data, 3) to work a PC as a local controller for the maintenance of the control object. So the data communication between the PC-IOC and the IO device is needed. They are directly connected with 100 Mbps LAN cable.

FieldPoint (National Instruments) is used for the IO devices, because of its reliability, hot plug and play operation, and good connectivity to the software environment. While FA-M3 PLC (Yokogawa Co., Ltd.) is employed for the magnet control both for the injector linac and for the storage ring, because we need a 16-bits resolution in main magnets power supplies and also needs synchronous ramping from injection energy (250 MeV) to operation energy (1.4 GeV) within a few minutes.

There are 5 Windows2000 PCs (2.66 GHz) running for the PC-IOC (fig.1). As the PC-IOC works as a local control machine during maintenance of the control object, the PC-IOCs are located close to their control objects. The ActiveX CA server applications running in the PC-IOC are developed by LabView (National Instruments). All of the control applications have been developed in the facility. Figure 2 shows a snapshot of the desktop window during the development of the CA server for the magnet power supply. It should be noted that the PLC control programs were developed by outside of the facility, Techno-AP (Ibaraki, Japan).

### Machine LAN

The data communication between the PC-IOCs (server) and the console PCs (client) is done via 100 Mbps LAN, which is isolated from the facility LAN and also isolated

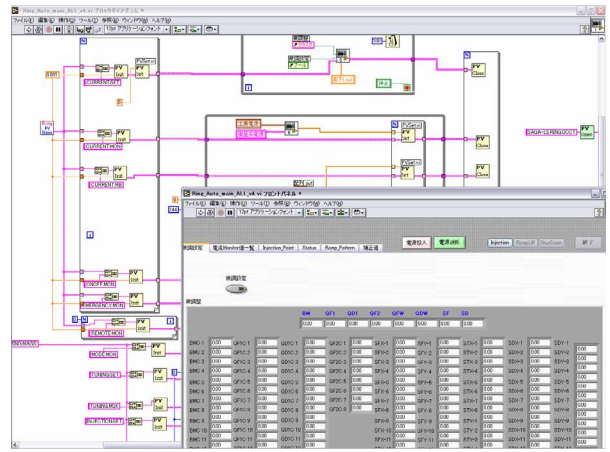


Figure 2: Snapshot of the desktop window of the CA server development.

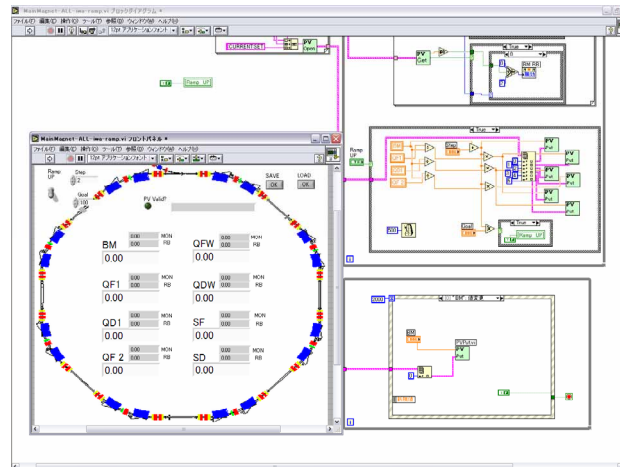


Figure 3: Snapshot of the desktop window of the CA client development.

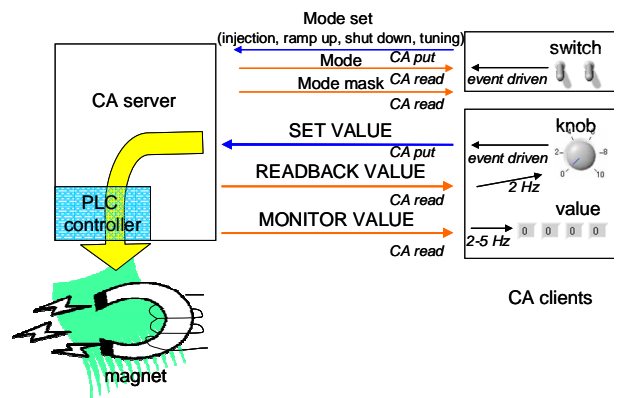


Figure 4: Configuration of the magnet control using ActiveX CA.

from the beam-line users. As is shown in figure 1, beam-line users will get the machine status via database system. An intra-web server will be used to extract information

from the database. Undulator users will be allowed to access to the undulator knobs, corrector magnets and tune correction quadrupoles. The subsystem of the beam-line users is under development and the details have not been fixed yet.

### Console PC

There are 8 Windows2000 PCs (2.66 GHz) running for the console PCs in the control room. Additionally a few notebook PCs also work as console PCs in the control room. The ActiveX CA client applications developed in-house by using LabView. Figure 3 shows a snapshot of the desktop window during the development of the CA client for the magnet power supply.

### ACTIVEX CA

As the ActiveX CA only supports the polling data transfer method, the communication rate between client and server is mainly limited by number of the process variable (PV). Thus "CA read" is driven by timer and the communication rate is 2-5 Hz in the present system, although the maximum rate is over 1 kHz for a single PV. On the other hand, we use "Event Structure", which is triggered with change-the-value events, in LabView for "CA put". In this case, almost no wait time is needed. However, we must combat with the synchronous problem in the client-server system. To resolve the problem we use "SET VALUE" and "READBACK VALUE" for "CA put". The "SET VALUE" is changed only by the client side and referenced in the server. On the other hand, the "READBACK VALUE" is periodically published from the server side. Figure 4 shows the configuration of the magnet control where "CA put" and "CA read" are used. Consequently the PV number in the magnet control of the storage ring is about 700 including control flags which are also shown in figure 4. Although the number of PV increases, we are satisfied with the overall performance of the present system. The ActiveX CA has the block data transfer method and the system performance would be improved to use this method.

### DATABASE SYSTEM

Database system is commonly used for an assistant of the daily operation, for a system diagnostic, and for displaying the historical trend of the machine. However, the ActiveX CA does not support the database function. So we added the database system. There are many available applications and LabView "Datalogging and Supervisory Control Module" (LV DSC). At first, we tried to use the LV DSC. However, LV DSC uses the OPC protocol and there are too many overhead with the ActiveX CA system. Then we've tried to use MySQL database. MySQL is open source software and widely use in many fields and we can communicate with MySQL via ODBC with LabView add-on module. The data logger applications running in the database PC also equip the ActiveX CA clients. About 600 PV data have been continuously logged into 8 tables in a period of a minute

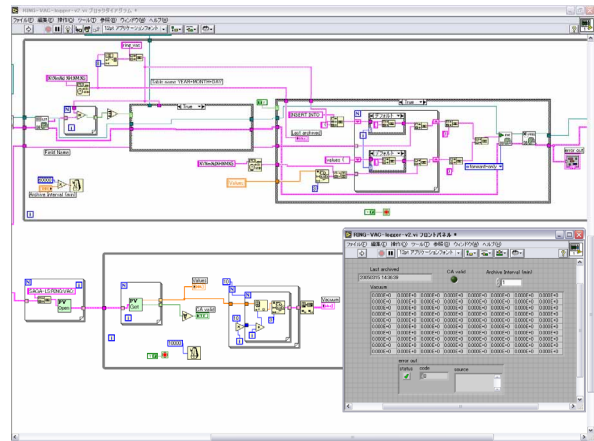


Figure 5: Snapshot of the desktop window of the data logger application development.

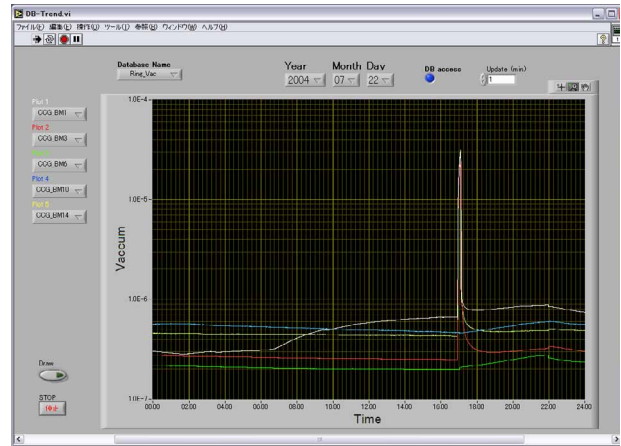


Figure 6: Historical trend graph of the storage ring vacuum monitor.

from February 2005 (partially started from July 2004). These tables are created every day to reduce the data access time. Figure 5 shows a snapshot of the desktop window during the development of the data logger application. Figure 6 shows a typical historical trend graph of the storage ring vacuum monitor. The database system has been working stably since July 2004. The large volume data, such as waveform of the linac beam monitor and CCD image data of the screen monitor will be added to the database.

### CONCLUSION

The control system of SAGA-LS has been constructed and operated from the beginning of the commissioning. A simple and robust control system with a reasonable cost by using ActiveX CA, LabView programming environment, and industrial IO device (FieldPoint and FA-M3 PLC) has been developed with small number of in-house staff. The system consists of PC directly

connected to the off-the-shelf IO devices (PC-IOC), console PC, and Ethernet LAN. The data transfer protocol is a subset of EPICS Channel Access (ActiveX CA). The total number of control object is about 500 and the total PV number is about 1500 at present stage. The system shows enough performance, 2-5 Hz of the communication rate, for the commissioning and for the normal operation. MySQL database system employed to fill the ActiveX CA vacancy. The database system has been working stably since July 2004. The MySQL serve will be used for the data server for the beam-line users.

Further improvement in the system performance may be required for the normal operation. In such case, standard EPICS system can seamlessly be introduced in some parts of the present system. The other approach is introducing OPC (OLE for process control) system[8]. OPC has widely been used in industrial field. Moreover, FieldPoint and FA-M3 PLC have their ready-to-use OPC servers. So we can access to the IO device directly from the console PC without any changes.

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