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In-House Control System for Medium Size Research Facility

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1. Introduction

A medium size research facility has a difficulties to develop control systems for their own special equipments, especially for accelerator facilities, because there is only few experts for constructing the control system and the control objects are not mass-product ones in most case. We have experienced such situation and we found a solution for a development in a medium size accelerator complex, SAGA Light Source (SAGA-LS) by using distributed MS-PC control system which is connected with a standard Internet protocol and is developed by Labview.

The SAGA Light Source (SAGA-LS) (Tomimasu, et al., 2003), (Iwasaki, et al., 2003) is a medium size synchrotron light research facility located at Kyusyu-Island, Japan. The accelerator control programs have been developed in-house from the beginning of the machine commissioning using Labview. At this stage almost all of the components of the accelerator, for instance, magnet power supplies, radio frequency (RF) system, vacuum monitoring and beam position monitoring system, are controlled and monitored by server and client model with LabView. During the commissioning period integrated sub-systems such as a feed-forward orbit correction system for insertion devices, a feedback power supply control system, a beam based beam position monitor (BPM) calibration and the other control applications have also been developed with Labview. E-mail services for alarm information and Web server that delivers accelerator status for entire facility are also developed by Labview. External codes are available to help the accelerator operation. For example TRACY2 (Nishimura, 1988) is used for accelerator modelling to establish the machine parameters in cooperate with Labview control system. In this chapter we describe the SAGA-LS accelerator control system as an example of developments of the control system for a medium size research facility using Labview.

2. Design

SAGA-LS accelerator consists of 255 MeV injector linac and 1.4 GeV electron storage ring. The circumference of the storage ring is 75.6 m. Figure 1 shows the geometrical layout of SAGA-LS facility. At this stage 10 beam lines are offered to user experiments.

The control system for the SAGA-LS accelerator, which consists of magnet power supplies, a radio frequency, and a vacuum monitoring system, should be implemented with communication interfaces, because those are distributed in wide area of the facility, and

operators have to manipulate these components from the control room. The Ethernet LAN is standard communication interfaces and we can easily use it with MS-PCs and LabView system with server and client model. We adopted Ethernet LAN as communication interfaces with each accelerator devices and PCs, because of its high cost performance. For the connectivity to the accelerator hardware, we selected commercial base off-the-shelf distributed input output devices (I/O devices) such as PLC (FA-M3; YOKOGAWA), and Fieldpoint (National Instruments). A serious issue on SAGA-LS facility is its tightly restricted budget and, hence, the limited number of staff in the facility. Thus, the control system for SAGA-LS should be simple and robust, while inexpensive, easy to develop, to maintain and to be expandable. The solution of this problem in the view point of hardware is the usage of the PC and the off-the-shelf products. On the other hand for the application developments we use the Labview environment, because a few number of staff have to develop the control applications with in-house efforts toward variety of demands from the construction period to the use operation period. Other reasons of using Labview and its merits are discussed in chapter 5.
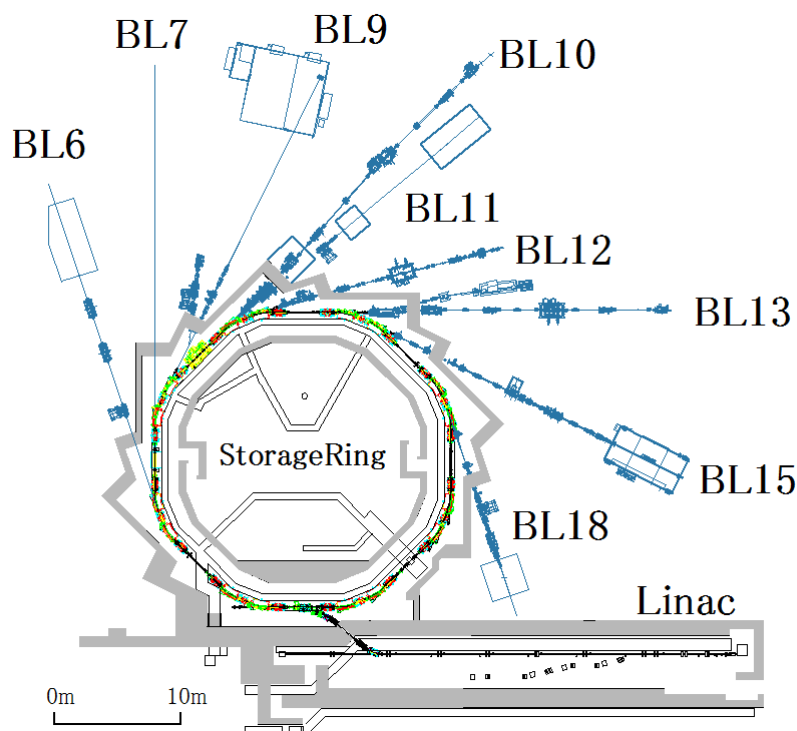

Fig. 1. Geometrical Layout of SAGA Light Source.

The PC control system is widely used in many facilities because of a very high cost performance of PC. On the other side, there are sophisticated and well-established control systems based on workstations, such as EPICS. It is an efficient way to use those resources to design a control system, because a many of hardware drivers and utility software specialized for accelerator control are available in EPICS system. PC-based EPICS system with the PC-UNIX operating system could also be an efficient way to design a control system, because we can use plenty of the existing resources. However, it is difficult to modify and expand the EPICS system with the limited number of accelerator staff, especially in the case without EPICS specialists. Fortunately, the number of the control items of the SAGA-LS is about 600 and there are very few demands for a real-time control. Only

exception is synchronous operation for power supplies for a quick energy ramping in the storage ring. In this case a PLC with preloaded ramping pattern is available. Hence, we have designed a MS-Windows PC-based control system, which uses the EPICS channel access (CA) only for the purpose of utilization of the general EPICS utility code, and off-the-shelf I/O devices. There are several manners to communicate with server PCs and client PCs. The DataSocket, Shared Variables, which in built–in protocol in the Labview system, are one of the methods for this purposes. But we use not only Labview, but also other programming tools for accelerator control system such as Delphi. ActiveX CA can be used under the any developing environment of MS-Windows OS. Thus we decide to use ActiveX CA as communication protocol for accelerator control system. There are several excellent works to develop CA components for the MS-Windows environment. ActiveX CA (Kay-Uwe Kasemir, 2000) is one of such component. The PC running the ActiveX CA server with I/O devices works as a standalone PC I/O controller which can communicate with the EPICS CA through the Labview interface.

Figure 2 shows the schematic view of the architecture of the SAGA-LS accelerator control system including beam line and office LAN. In figure 2, the RF powe supplies of linac, electron gun and the many kinds of beam diagnostic equipments are omitted.
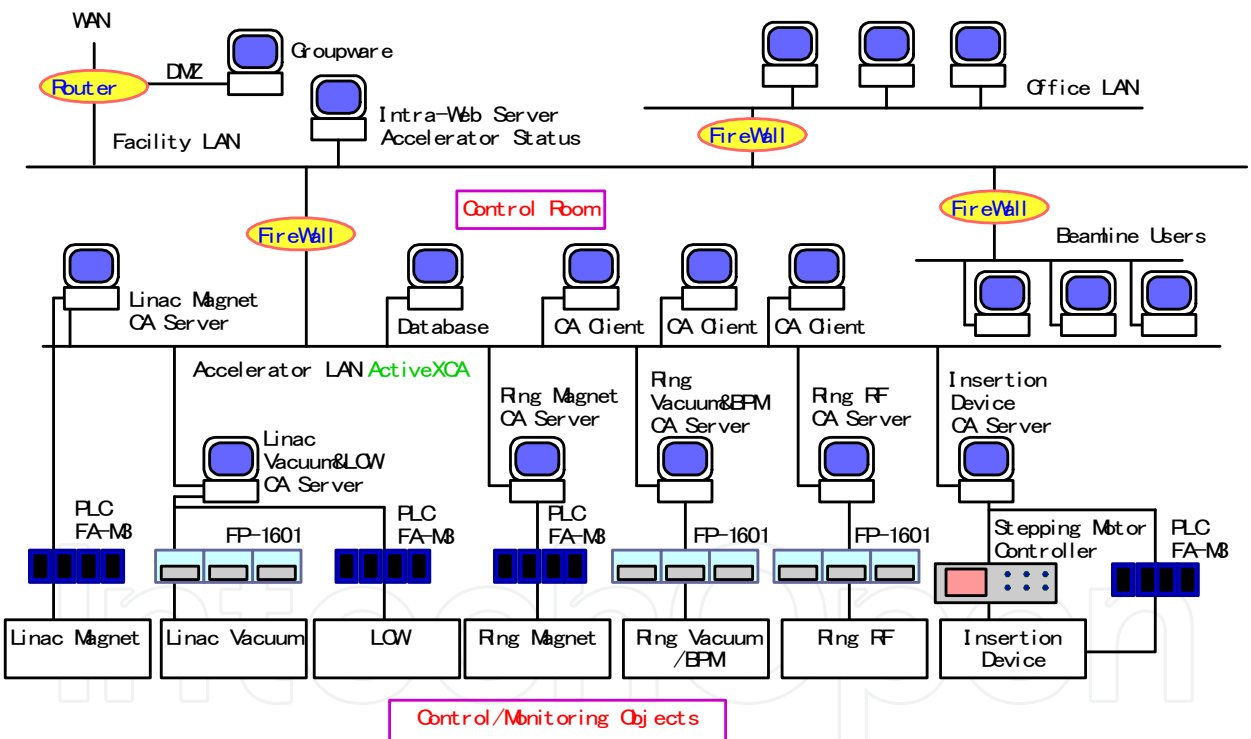

Fig. 2. Schematic view of the architecture for SAGA-LS accelerator control system.

The accelerator, beam line and office LAN are separated by firewalls to secure the accelerator cotrol network. To control the insertion devices from the beam line users, for instance the operation of undulators, an exception of security policy is added in accelerator firewall. Simple TCP/IP protocol is used for control method of insertion devices from the beam line users. An intra-web server is placed in middle zone of facility LAN to deliver the machine parameter in any location of the SAGA-LS facility. The intra-web server delivers the status of the accelerator for the beam line users. The details of web system and E-mail system are described in section 5.7.

3. System Implementation

3.1 Console PC

The machine commissioning of SAGA-LS accelerator was begun on 2004, and we selected Window 2000 as operating system of server and client PCs because of its stability, and MS-Windows OS is familiar environment for the facility staff. The cost performance of Windows PC is one of the reasons for the choice. At the present stage the higher version of MS-Windows OS, i.e., Windows XP, Windows Vista and Windows 7 is also used for new control components of the accelerator.

Console applications are developed using Labview with ActiveX CA. The client PC communicates with not only one server PC but also several servers for the purposes of cross sectional applications: COD correction program, measurement of response matrix (R-matrix), beam based BPM calibration and so on. A few example of console programs will be described in section 5.2, 5.3 and 5.4.

The data archive system (Database; MySQL), which records accelerator parameters is installed in the system. The logger programs and the trend viewers are constructed using Delphi and Labview respectively. ODBC is used for connecting MySQL with Labview.

3.2 PC-IOC

Recent industrial IO devices are reliable and high-speed access via built-in Ethernet modules can be available. Thus we construct the IOC only with such off-the-shelf industrial I/O devices. We put PCs between the console computers and the I/O devices, because:

I.   Industrial I/O device itself cannot directly communicate with consol PC with ActiveX CA.
II. Server PC can be used as a local controller during installation and maintenance.
III. Server PC works as IOC for GPIB and non-Ethernet devices such as digital voltage meter.
IV. The device LAN should be separated from the facility LAN to secure the network.

FieldPoints are a candidate for the I/O devices, because of its reliability and hot plug and play operation, and good connectivity to the software environment of Labview. FA-M3s (Yokogawa; PLCs) are used for the I/O devices for magnet power supplies, cooling water system and insertion devices. Digital voltage meter, which monitors the beam current in electron storage ring, is connected to a beam current monitor PC with GPIB. As the PC-IOC works as a local control machine for the maintenance, i.e. repairing or conditioning, the PC-IOCs should be located close to their control objects.

There are over 10 Windows 2000 or Windows XP PCs for PC-IOC that equipped with ActeveX CA servers. The server applications have been also developed with Labview. Almost all of the control applications have been developed in the facility. The only exception is PLC program for magnet power supplies those are developed by Techno-AP (Ibaraki, Japan) at first stage of installation. The PLC program has been modified by the facility staff.

3.3 Performance

The data communications between the PC-IOCs (servers) and the consol PCs (clients) are done via 100 Mbps LAN, which is isolated from the facility LAN and from the beam-line users by firewall.

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). Further more, we must combat with the data-synchronous problem in the multi-client system. To resolve the problem we use "SET VALUE" and "READBACK VALUE" for "CA put." In figure 3, the method using "SET VALUE" and "READBACK VALUE" is illustrated. Nominal communication rate for 144 variables of magnet power supply for storage ring are about 5 Hz in the present system. Further improvement in the communication rate can be expected by using the block data transfer method in the ActiveX CA. Feasible studies on the block data transfer to the magnet power supply in the storage ring shows that the communication rate can be achieved 9.5 ms/144 data. However, the block data transfer method looses simplicity and flexibility in the development of the client applications. Therefore we use block data transfer method only for the client PC which is required for a synchronous operation between many power supplies, such as COD correction client. The Windows PCs and ActiveX CA satisfy our demand with the communication rate of 1 to 10 Hz. The details of design, implementation, performance of the control system of SAGA-LS are summarized in references (Ohgaki et al., 2003), (Ohgaki et al., 2005).
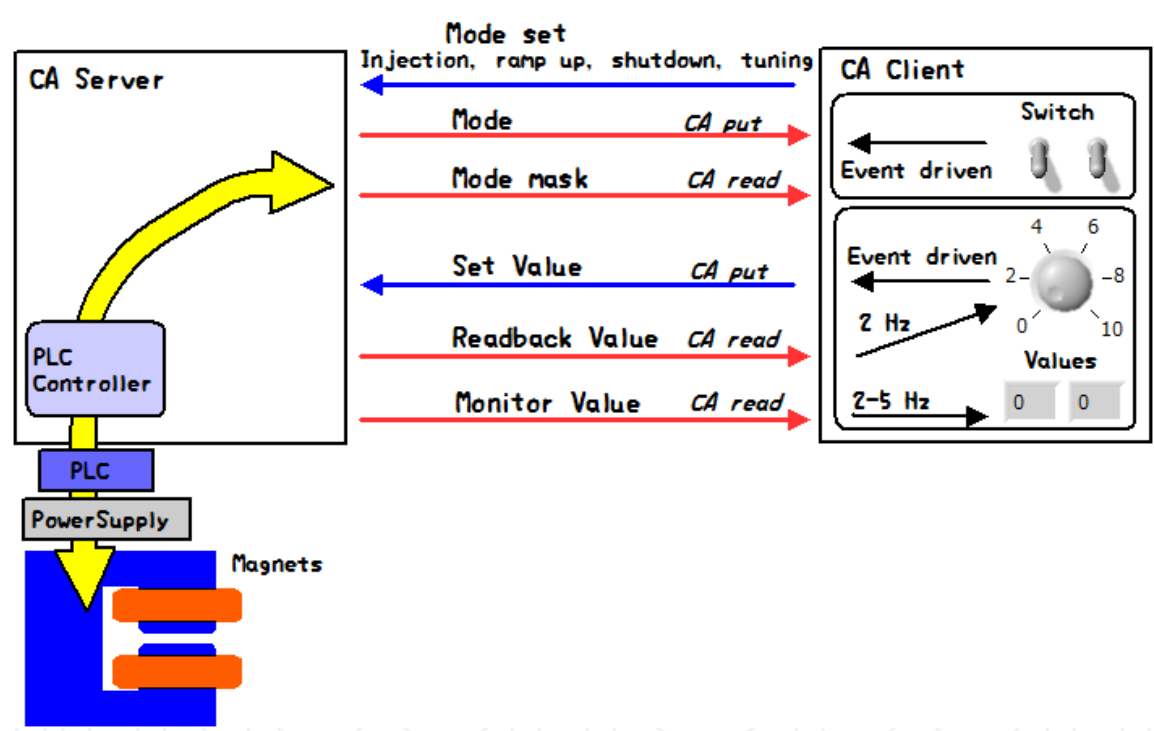

Fig. 3. PV configuration of the magnet control system using ActiveX CA.

4. Example of application programs

4.1 Magnet power supply

The purpose of control system for magnet power supply is simple: to switch on/off the power supply; to change and monitor the output current; to indicate interlock alarms; to inform the status: However there are 144 magnet power supplies in SAGA-LS electron storage ring, and these must be controlled synchronously during the energy ramping operation, otherwise, a large orbit shit of electron beam or a serious beam instability will be occurred, and in worse case the stored beam will be lost.

To fulfil the requirement for the magnet power supply control sub-system, we adopted PLC as a control device. PLC is used to guarantee the synchronous and rapid operation. The synchronization accuracy of PLC is sufficient for our requirement (within 10ms coincidence). For the energy ramping up, the ramping pattern whose step size are 10,000 points per each magnets are pre-loaded in the file registry of the PLC.

PC program, which is developed by Labiview, thus, have two main routines. One is for connection to the PLC to control and to receive status from the power supplies. And the other routine is to accept demands from the external client PC for the orbit correction, for instance. As described before, the communication between server PC and client PC is done by ActiveX CA. In Figure 4, front panel of control application for magnet power supply and block diagram are shown.

Typical feature of this application program is that we use "Queue with Type Definition File" so that many series of tasks are not conflicted each other. By using "Queue with Type Definition File", the drawn area of block diagram becomes to be compact compared to using the other syntax. The scalability of "Queue" for new procedure is quite simple. Basically this magnet program and ladder program of PLC is developed by Techno-AP (Ibaraki, Japan), and modified by SAGA-LS staff for further development of machine operation. The functions of the feed-forward control of power supply for insertion devices and feedback control for stabilisation of power supply have implemented in the program as well. The details of feed-forward and feedback system will be mentioned in section 5.5 and 5.6 respectively.
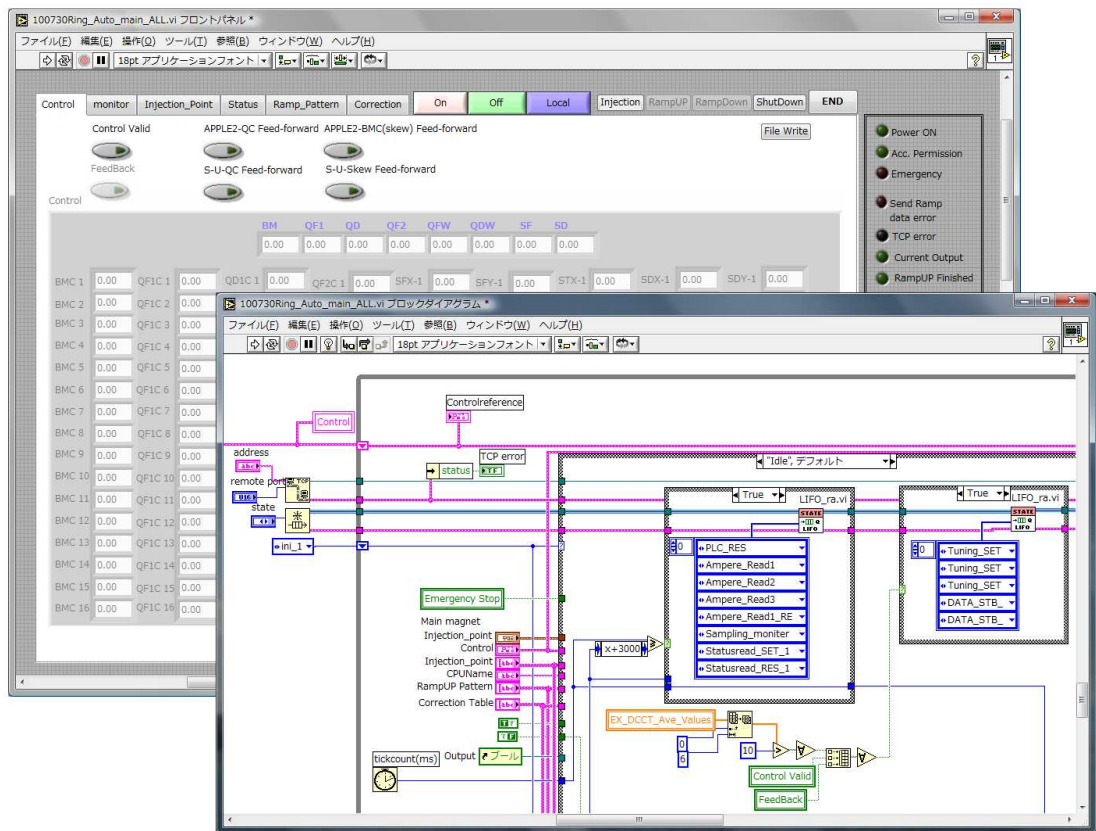

Fig. 4. Front panel and block diagram of the storage ring power supply control application. We are sorry that some words are written in Japanese, because we use Japanese version of Labview.

4.2 Vacuum monitoring

The electron beams circulating in the storage ring is scattered by residual molecules and stored current is gradually degreasing. To maintain a long lifetime of the electron beam, the pressure level of the accelerator must keep in an ultra-high vacuum. Hence the monitoring of the vacuum level is important for a stable accelerator operation. The vacuum level is measured by the vacuum gauge, and the analogue signal from the gauge controller is collected using a Fieldpoint 16bit ADC. The vacuum server PC translates the analogue signals to physical values and put the value as Process Variables (PVs). The sever PC and Fieldpoint configured PC-IOC. There are 24 vacuum gauges in the storage ring and 3 gauges in front end of beam lines where the beam profiles are measured. In the beam transport line near the injection septum magnet there is a vacuum gauge as well. All of the vacuum levels are
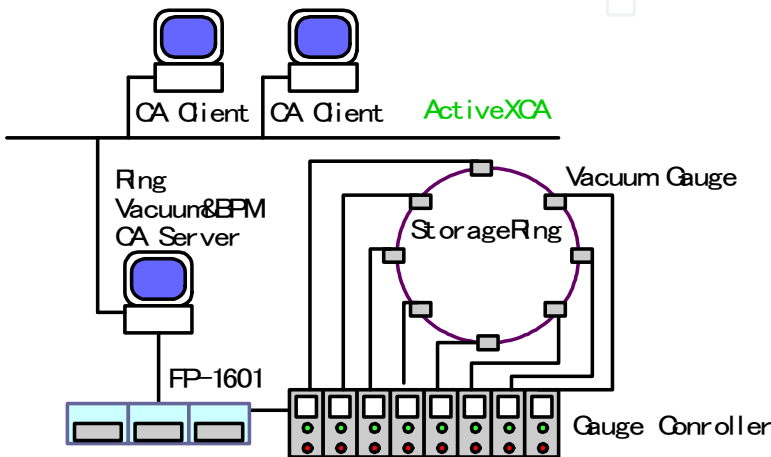

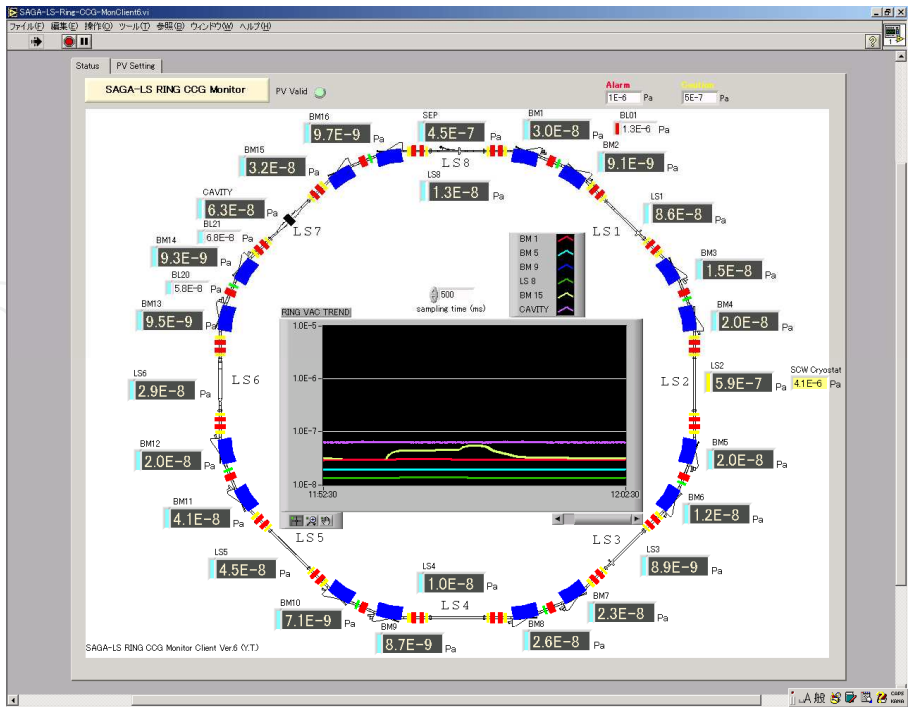Fig. 5. Schematic view of vacuum monitoring system of SAGA-LS accelerator.

Fig. 6. Front panel of vacuum monitoring system. The vacuum is indicated not only as digital numbers but also trend graph. Vacuum levels of the ring are alarmed using colored indicator.

monitored from the control room and recorded into the database. Figure 5 shows the schematic view of the vacuum monitoring system of SAGA-LS accelerator. The vacuum server PC also serves the beam position to reduce the number of server PC. The trend of the vacuum level is graphically indicated in the front panel of the client PC as illustrated in figure 6. The easiness of construction of front panel and adequate graphical interfaces are superior points of Labview environment.

4.3 Beam position monitoring and closed orbit distortion correction

Beam line users use the synchrotron light emitted from the bending magnet or from the insertion devices. If the beam positions are not well defined, the path of the light would be changed, and it causes the fluctuation of the exposure light on the sample specimen. Thus the beam orbit should be corrected. Furthermore if the electron beams pass though the peripheral part of the quadrupole magnet, the electrons are affected by the multipole magnetic field, and it makes the accelerator parameter (such as twiss function) distorted, and a beam instability would be arose. Therefore the beam orbit is fixed to the center of magnetic field of the quadrupole magnets. The beam positions are measured using pick-up electrode and the signals are processed using BPM electrical circuit. DC voltage signals are read with Fieldpoint 16bit ADC, and the DC signals are translated to the physical values in the BPM server PC.

Here we briefly describe the principle of closed orbit distortion (COD) correction. If the $\vec{x}$ and $\vec{\theta}$ are the vector of beam positions measured by BPMs and the vector of kicks by the quadrupole magnets respectively, there is a linear relation with these quantities, $\vec{x} = \mathbf{R}\vec{\theta}$. $\mathbf{R}$ is called orbit response matrix. The matrix element of matrix $\mathbf{R}$ is the single kick response to a BPM. If the inverse matrix of $\mathbf{R}$ is obtained, the kick angles to correct the orbit distortions are represented as $\vec{\theta} = \mathbf{R}^{-1}\vec{x}$. Although the response matrix can be calculated with a simulation code by using the machine parameters (strengths of the quadrupole magnets and kick angle of steering magnet), but the response matrix is directly measured by the beam behaviour with kicks of the steering magnets and with monitoring by the beam positions in our case. We obtained measured orbit response matrix as follows:

I. Measure the beam orbit without kicks
II. Excite a steering magnet;
III. Measure the orbit shift
IV. Turn off the steering magnet
V. Repeat these procedures until all of the steering magnets are excited.

After the measurement of orbit response matrix, the orbit distortions are corrected with the corresponding steering kicks. The inverse of matrix $\mathbf{R}$ is driven using the method of Singular Value Decomposition (SVD), of which procedure is included in Labview mathematical library. This is also the great advantage to use Labview. The accuracy of correcting the COD against the reference orbit is less than 20μm in both directions with 24 BPMs at SAGA-LS storage ring. Figure 7 shows the front panel of COD correction program.

4.4 Beam based beam position monitor calibration

As is described in previous section, the electron beams circulating in the storage ring is measured by BPMs. Usually BPMs are aligned to the center of the quadrupole magnet, but the electric center of the BPM does not correspond to the center of the quadrupole magnetic field by the initial setting of the installations. If the beams pass through the off-center of the
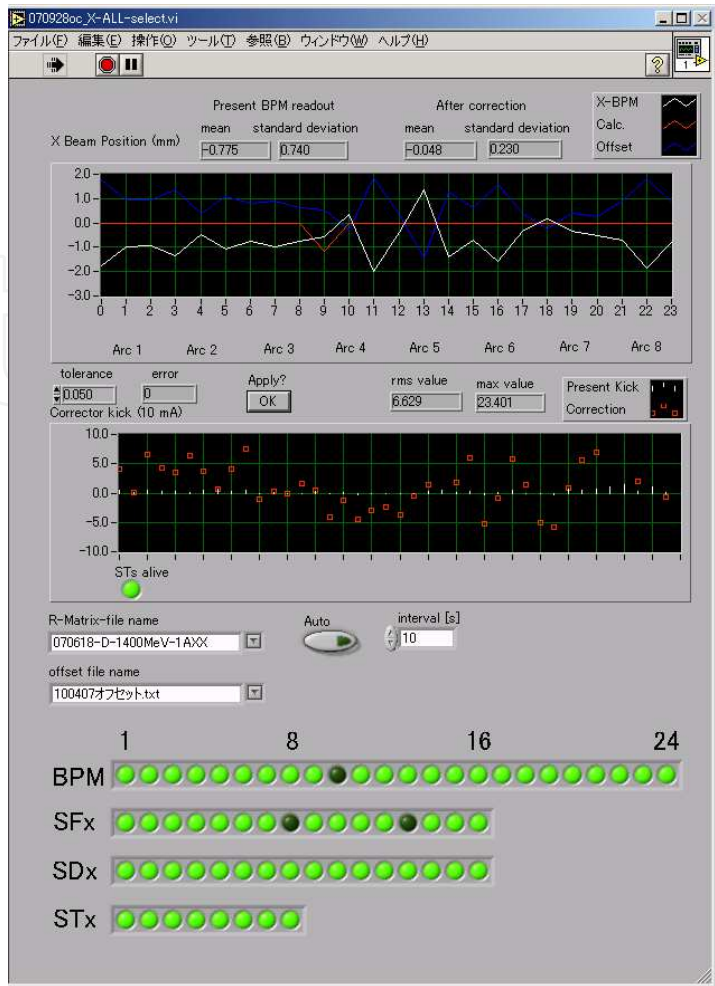
Fig. 7. Front panel of COD correction program. Any BPM and steering magnet can be selected (or masked) for the correction.

quadrupole magnet, the beam is kicked with the multipole magnetic field. Such multipole field causes the orbit shift and decreases the dynamic aperture, which limits beam lifetime. Thus the calibration of the BPM to the magnetic center of the quadrupole magnet is significantly important.

The method of beam based BPM calibration is follows;

I.   Generate bump orbit near the BPM to be calibrated.
II.   Change the excited current of quadrupole magnet close to the calibrated BPM.
III. Measure the orbit shift by the other BPMs in the storage ring.
IV.   If the beam passes though the center of quadrupole, might become to be zero.

On these procedures, the steering and quadrupole magnets are sequentially exited and beam positions are measured. The BPM offset is analysed using Labview on line. In the analysis linear fitting routine included in Labview mathematical library is used. The application of the beam based BPM calibration automatically change the value of the steering and the quadrupole magnets, and monitors the beam position. Such complex and multi-task application is performed by networking and multi-client architecture with ActiveX CA data communication. Figure 8 illustrates the method of BPM calibration. By using the beam based BPM calibration, it was found that over 1mm offset in maximum are existed in the SAGA-LS storage ring.
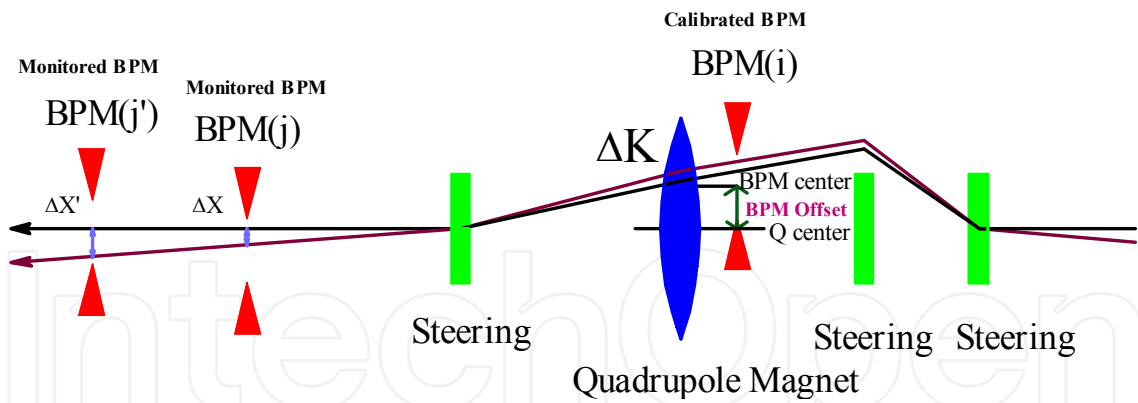
Fig. 8. Method of beam based BPM calibration.

4.5 Feed-forward correction of orbit, tune shift, skew correction

In SAGA-LS storage ring, there is a planner undulator and an APPLE-II undulator. The APPLE-II type undulator is a kind of undulator, which varies not only the photon energy but also the polarization of photon beams. Therefore, the control system should be prepared to control the gap and the phase of undulator without changing the electron beam orbit and size. The magnetic fields of the undulators are carefully measure and adjusted before installation, but the residual dipole magnetic field and quadrupole and skew quadrupole magnetic field are not completely compensated in general. The residual dipole field causes the orbit shift and quadrupole and skew quadrupole component change the beam size. For the free operation from the undulator users during the machine operation, these magnetic fields should be automatically compensated by an external magnetic field. The residual field is a unique function to the gap and the phase of the undulator, hence we have constructed feed-forward magnetic compensation system. The server PC of the magnet power supply reads the gap and the phase in the interval of 0.1 sec, and automatically produces the corresponding exciting current to the dipole magnet, the quadrupole and the skew
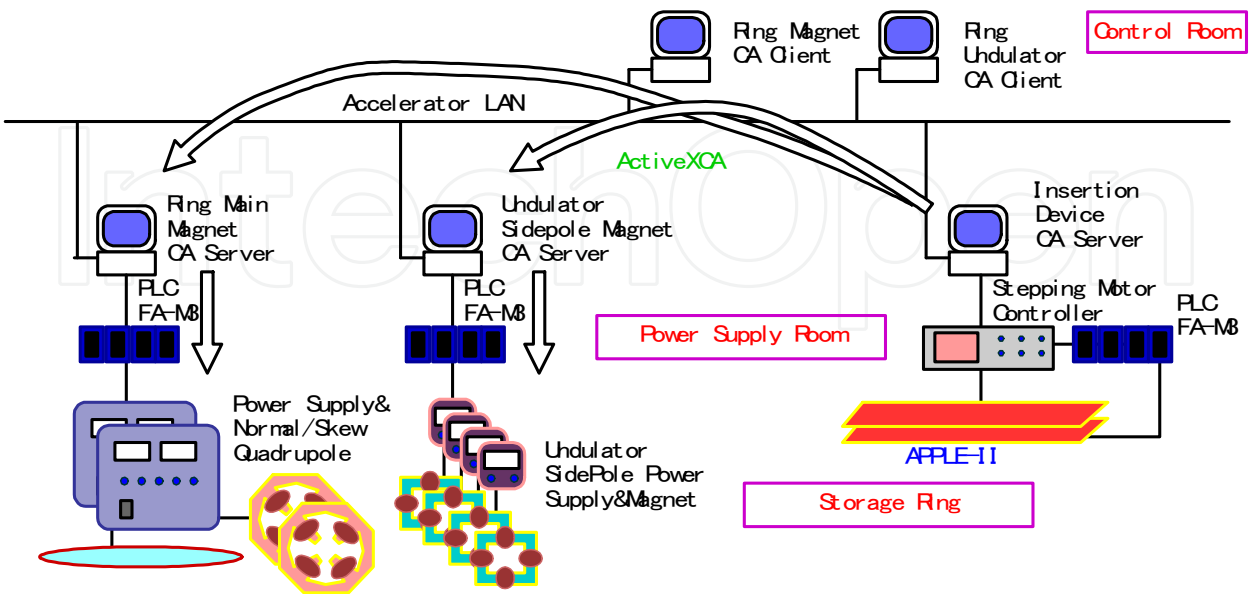

Fig. 9. Feed-forward dipole, quadrupole, and skew quadrupole magnet against gap height and phase position of the APPLE2.
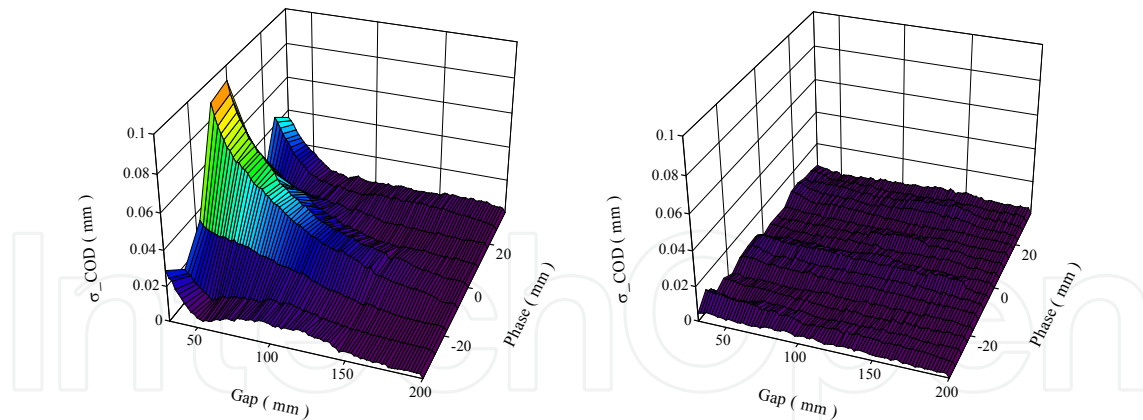
Fig. 10. Result of feed-forward dipole correction. The figure shows the horizontal COD: before; right, after; left. The COD have been reduced less than 10 μm by feed-forward correction system, and this result confirms the free operation of the undulator from the beam line users.

quadrupole magnets. In that case, the magnet server PC acts as a client PC for undulators. The magnet currents have been determined from the experimentally measured values. However the experimental data are the discrete set against the gap and the phase, the feed-forward correction application program calculates the exciting current with an arbitrary point by the linear and the polynomial interpolation of the measured data. Figure 9 shows the schematic view of the feed-forward system, and figure 10 is the correction result of the horizontal orbit shift. Before the correction, the standard division of the COD against the reference orbit is larger than 100 μm. After the correction it was reduced to be less than 10 μm.

4.6 Feedback system of magnet power supply

Magnet power supplies excite the magnets to produce required magnetic field. When the exciting current of the power supplies are drifting, we observe the tune shift and it causes, variation of the beam size and the beam lifetime. Although the output current is monitored through Digital Analogue converter (DAC) in the power supplies and PLC, the accuracy of the DAC is not sufficient for the beam diagnostics at the early stage of the user operation. To prevent these fluctuation we have installed an external DC current transformer (DCCT) to monitor the current with an accuracy of $\pm 1 \times 10^{-4}$, whose uncertainty dominantly comes from the accuracy of the Fieldpoint 16bit ADC. By measuring the output currents of the power supplies, we clearly found the source of the tune shift.

After constructed the monitoring system of the output current of power supplies, we developed a slow feedback system of the magnet power supply. The output currents are measured external DCCT, and the signals are processed by DCCT electric circuit. The output voltages from the DCCT electric circuits are collected by the Fieldpoint ADC in 1Hz. Figure 11 shows the configuration of the slow feedback system for the magnet power supply. With this system the accuracy of the set point and the drift is $\pm 2 \times 10^{-4}$. In figure 12 measured fluctuations of the output currents of the quadurapoles are shown. There still exist unexpected tune shifts in SAGA-LS storage ring. The fluctuation of the cooling water temperature of the magnets and the room temperature of the storage ring could be a possible source of the unexpected tune shift.
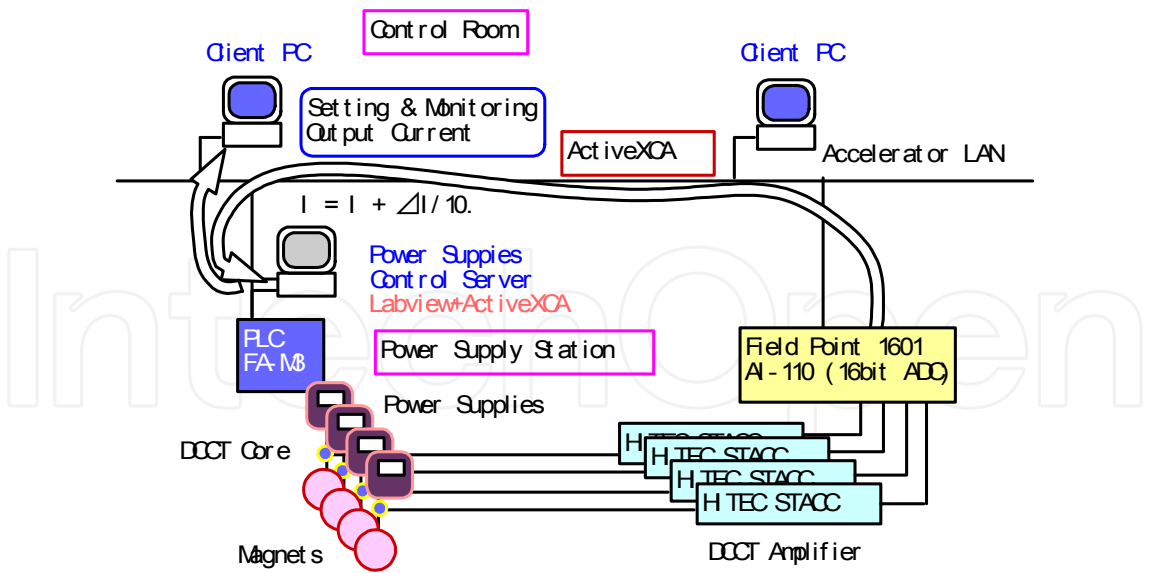
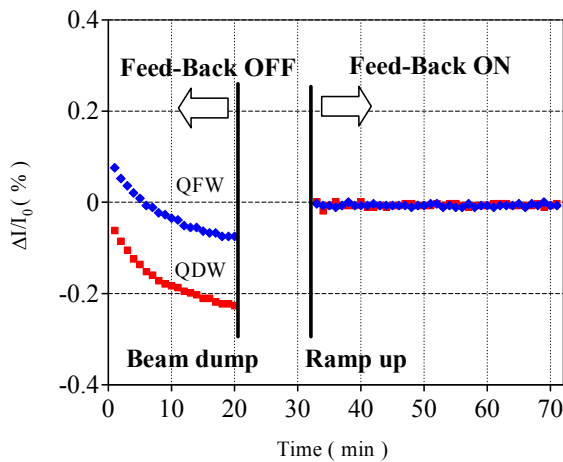Fig. 11. Schematic view of slow feedback system of magnet power supplies. .

Fig. 12. The trend graph of output current of magnet power supplies (QFW and QDW). With the feedback system, the drifts of the power supplies are clearly reduced.

4.7 Web system, FTP, and E-mail system

In the present system we offer the accelerator status, such as the stored current, the electron energy, the position of the insertion devices, the mode of operation and so on, by using an inter-web server installed in the intermediate zone of the facility LAN. We use "APACHE" server as the web server, and Labview is used for generating the html file with NI Report Libraries. The trend of the stored current is drawn by the MySQL database. Figure 13 illustrates the web image of the intra-web.

The inter-web server also produces quasi-real time (1Hz) status services within our facility for the beam line experiments and alarm monitors. An exception of firewall policy is added to the accelerator firewall. Simple TCP/IP protocol is used for such application programs, because ActiveX CA uses several ports and it might be dangerous for the accelerator LAN.

For delivering the major parameter of the accelerator to the public via World Wide Web, we are prepared the external web server with the global IP address. To send the front panel image (jpeg image), we use an FTP client program, which was downloaded from the NI

Developer Zone (National Instruments) and was modified for our demands. A lot of sample programs are bundled in the Labview package and further sample programs are stored in the NI Developer Zone where we can discuss about our problems in the Labview developing environment and the development of applications.
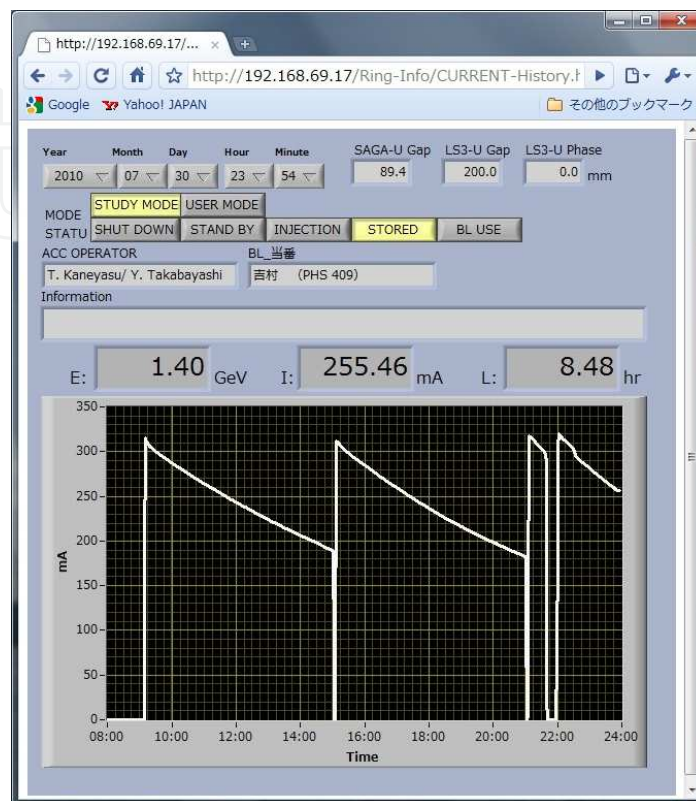

Fig. 13. Image of intra-web service at the machine study mode.

At present day, almost all people have their own mobile phone. The E-mail system also is developed for users to get the details of the accelerator status, for instance, the vacuum levels, the temperature of cooling water, etc. The procedures of the E-mail application are follows: when users send the message to the E-mail server, the E-mail client quickly receives the mssage from the E-mail server and resolves the mail subject, and replies to the address with required accelerator parameter as a message. Figure 13 is the block diagram of the E-mail application and sub VI. Basic program of the E-mail receiver and sender are also downloaded from the NI Developer Zone. In our E-mail sending the authentication method of MD5 is required from the E-mail server. Thus, we implement the function to the E-mail sender via RFC configuration scheme. Alarm system of the accelerator is also implemented in the E-mail application program.

5. Accelerator model calibration with external code TRACY2

The method of accelerator modelling by fitting the measured response matrix with calculated orbit response matrix is well known and widely adopted to many light sources for stable operations (Safranek, 1997), we also examined the procedure to diagnose the machine optics and to restore the periodicity of the twiss functions. In the analysis we use the tracking code TRACY2, and Labview can call this code as an external code in the application programs.
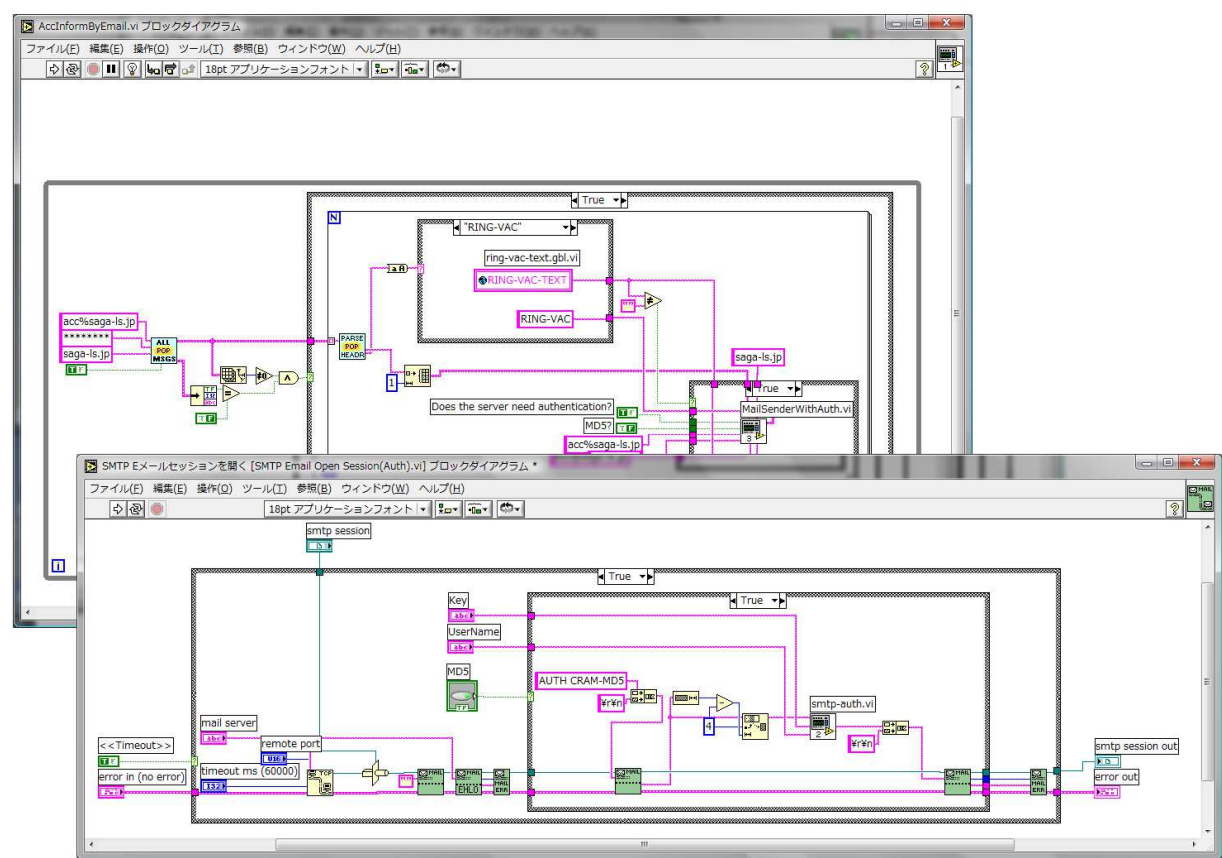
Fig. 14. Block diagrams of the E-mail application and its sub VI.

The orbit response matrix is defined by a variation of COD, which results from unit kick by a steering magnet. The matrix element R_{ij} represents the orbit shift at the i-th BPM caused by a unit kick from the j-th steering magnet. The subject is finding best-fit parameters of which maximum likelihood reproduce the experimentally obtained data. Such parameters could be found by minimizing the quantity χ^2. In our problems χ^2 is defined as follows,

$$\chi^2 \equiv \sum_{i,j} \frac{(R_{[\text{model}]i,j} - R_{[\text{measu}]i,j})^2}{\sigma_{ij}^2} \tag{1}$$
$$i = 1,2,\cdots,M, j = 1,2,\cdots,N$$

where $R_{[\text{model}]i,j}$, $R_{[\text{measu}]i,j}$ and σ_{ij}^2 are the calculated and the measured response matrix elements and the standard deviation of the measurement errors in the beam position, respectively. M and N denote the numbers of the BPMs and the steering magnets. In such fitting problems the SVD method is a standard solving technique (William, et al.,). SVD is also used to resolve the COD as already mentioned in section 5.3. Here, we will resolve 168 parameters with 1872 conditions.

Although it is not mathematically clear that the all parameters can be exactly resolved or have unique solution in principle, because the response matrix is not a linear function of the quadrupole strength. To confirm whether the fitting procedure could derive a unique solution or not, and exactly reproduce the parameters under the condition of the SAGA-LS lattice

formation, firstly we simulated the ideal case in which the measurement errors are neglected. At the simulation, we prepared the calculated response matrix with randomly distributed parameter sets. Then we adopted the fitting to the calculated response matrix. Figure 15 shows the result of the simulation of the fitting for the quadrupole strength of QF1. After 5 iterations all parameters of QF1 was completely converged to originally setting values.
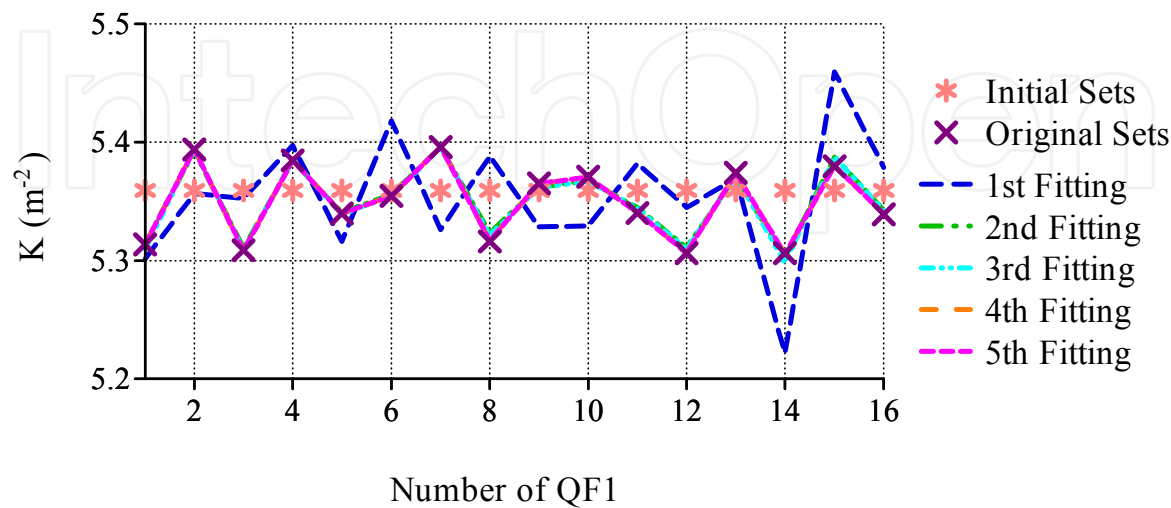

Fig. 15. Fitting transition of the QF1 K-values. After 5th iteration the fitting procedure completely reproduce the original set points.
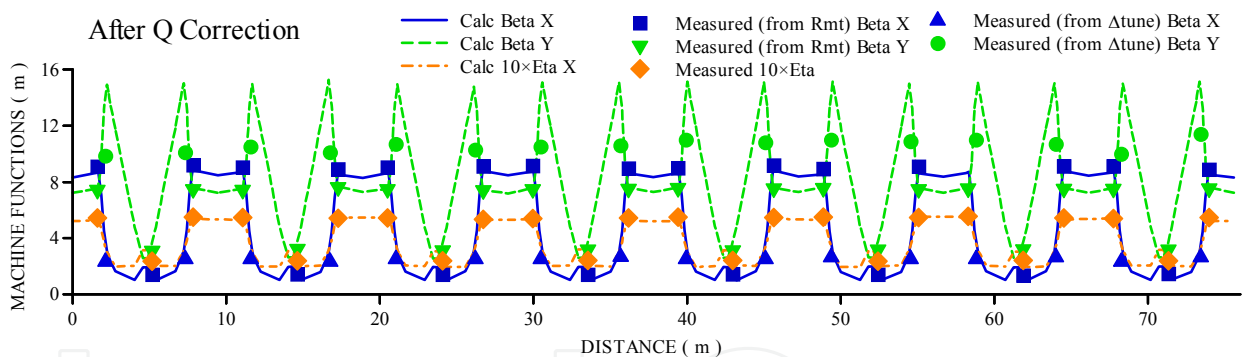

Fig. 16. Calculated and measured twiss functions after the quadrupole correction.

Figure 16 is the correction result of twiss function after the parameter fitting. We confirmed that there was no significant distortion in the twiss function in the storage ring and a good periodicity in the twiss function was observed. This method is useful for the accelerator diagnostic, because if one of the quadrupole magnet the irregularity of the twiss function is observed, and this response matrix fitting procedure can indicate the wrong component.

6. Future plan

6.1 Present status of the control system and its problems
The in-house Labview based control system stably works. The communication speed of the control parameter is about 10 Hz which is high enough for daily operation of the facility. Almost all accelerator components are integrated into the present system except for timing system which will be included in 2011.

Partially we use Labview8.5 running on Windows 7 and there is no problem between the old version of Labview (7.1) and the Windows XP including ActiveX CA communication. However, we still have problems, as;

1. client PCs for the data communication between the MySQL database and Labview sometimes hung up.
2. AD conversion speed of the Fieldpoint 16-bit ADC (1 Hz) is the bottleneck of the system performance of BPMs and vacuum monitor.
3. The number of the control PCs (server PCs and client PCs) are increased rapidly and this causes heavy maintenance load for operator. This also causes human errors in operation.

Therefore we are going to improve our system in the following cares.

I.   Selection of database system including Labview DSC system
II. Replacement of the Fieldpoint to CompactRIO
III. Development of integrated client program
IV. Integration of server PCs to reduce the number of the control PC.

6.2 Improvement of user interfaces

In this section we will describe our recent improvement concerning to the III listed in the previous section.

From the commissioning period the number of the accelerator components has been increased rapidly. Especially the increasing the number of the client PC makes the operation complex. At the present stage we have to do 20 steps to offering the synchrotron radiation light to the experimental users. The complexity of machine operation sometimes causes human errors. Therefore we intend to improve the interface of the machine operation.
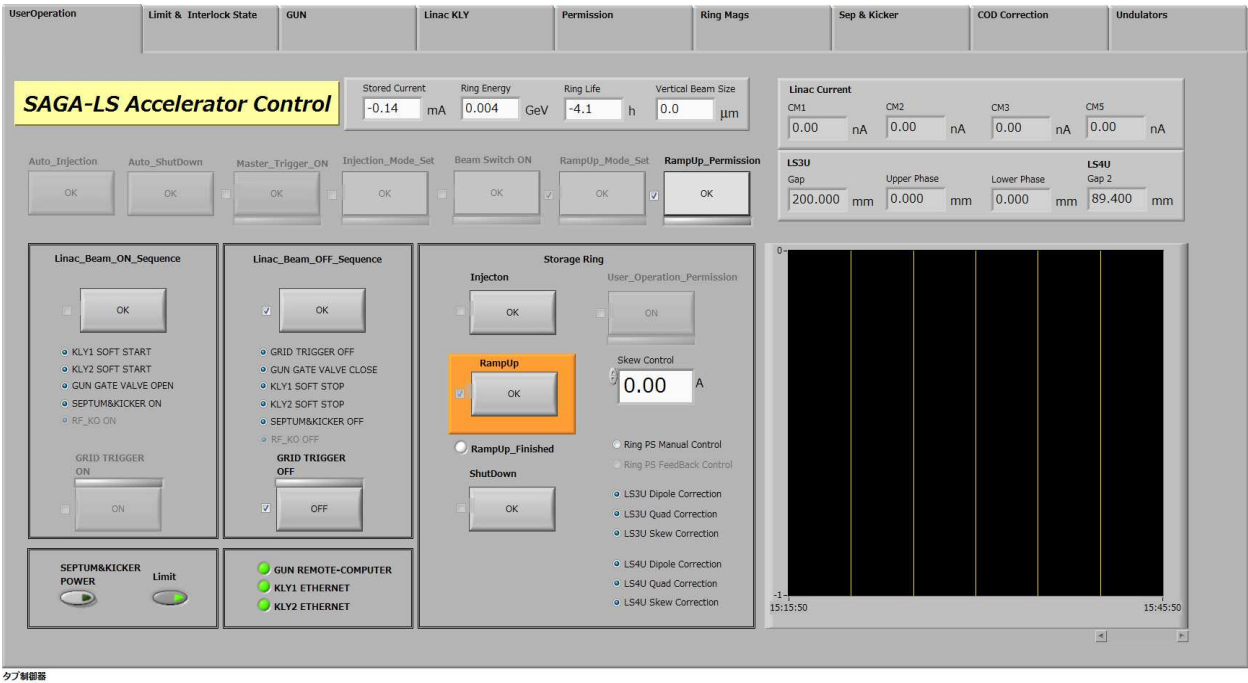

Fig. 17. Front panel of multi-purpose client PC. The program is running on Windows 7 and touch panel display. User can access each button intuitively without using a mouse.

We are developing a multi-purpose client program to integrate the client PCs to avoid human errors based on the operation complexity. The multi-purpose client program also adopted sequential programming which automatically sets accelerator parameters. We employed a touch panel display for an intuitive manipulation of operation of the accelerator as well. Figure 17 is the front panel of the newly developed multi-purpose client PC running on Windows 7. In this program "Tab button" is used for the individual programs. To reduce the operation procedure, the radiation interlock system is also integrated into this system. Although some parts of component concerning to the interlock system, such as master trigger, is not included in the system at this stage, the operation is significantly improved. After the all accelerator components are integrated into one, we expect that we can offer the synchrotron light to beam line users with only one-touch. The shutdown process will be also simplified. Sequential programming is done with Labview "stuck sequence structure" and with local variables. The easiness of multi-threads programming and sequential programming is also one of advantage of Labview.

6.3 Model based control system

The idea of model based control system is that operator controls accelerator with desired physical values calculated from a simulation code. At the beginning of the machine commissioning the first purpose of the control system is to put on/off the switch, change the machine parameters from remote location (control room). The machine parameters are manipulated so that the accelerator working as the desired manners. But we have mentioned in chapter 6 the measurement parameters of the accelerator are sometimes different from the designed values. The reasons of differences are, the measurement errors, calibration error of the power supplies of magnets, the non-linearity of the BPM gain, rotation of the BPM, misalignment of the magnets, the coupling of magnetic field that is caused by the adjoining magnet, and so on, that varies the accelerator parameter. Thus the beam based accelerator calibration is important to estimate the actual machine parameters and thus to estimate the machine status.

After the machine parameters are fixed and the machine works stably, usually the machine parameters do not need to be changed in daily operation at light source facilities. However, when the new operating point of the accelerator is required, the model based control system is useful. Because corresponding new machine parameter can be derived with the model calculation. We will develop the model based control system with Labview, which can execute external code and dynamic link library for beam behavior simulations in the accelerator. GOEMON (Nishimura) is the dynamic link library for the simulation code of storage ring, and ELEGANT (Borland) is for linac.

7. Conclusion

We have been developed in-house PC based control system for the medium size accelerator facility, SAGA-LS. The control program has been developed by Labview with ActiveX CA for distributed client-server system. With the easiness and flexibility environment of PC-Labview, daily control tools for the facility have been rapidly constructed by in-house resources. The successful improvements of the Labview application programs are helped by the sophisticated sample program bundled with Labview and also sample programs in the NI Developer Zone. Multi-thread and sequentially procedure, mathematical library, report generation library greatly reduces the development time. Multi-purpose CA client program

has been developed with touch panel display on Windows 7 to improve the user operation interfaces. In the model calibration of the accelerator program the external code TRACY2 is also implemented. We are intending to implement the accelerator code GOEMON, which is the DLL version of TRACY2, to our control system.

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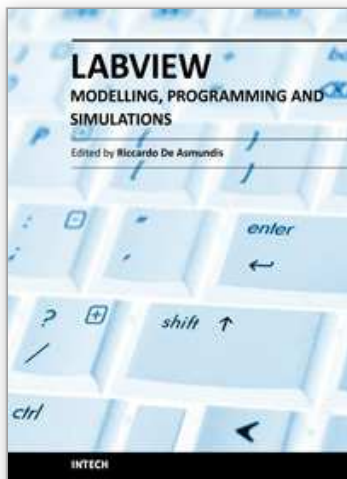
Modeling, Programming and Simulations Using LabVIEW™ Software

Edited by Dr Riccardo De Asmundis

Born originally as a software for instrumentation control, LabVIEW became quickly a very powerful programming language, having some characteristics which made it unique: simplicity in creating very effective User Interfaces and the G programming mode. While the former allows for the design of very professional control panels and whole applications, complete with features for distributing and installing them, the latter represents an innovative way of programming: the graphical representation of the code. The surprising aspect is that such a way of conceiving algorithms is extremely similar to the SADT method (Structured Analysis and Design Technique) introduced by Douglas T. Ross and SofTech, Inc. (USA) in 1969 from an original idea by MIT, and extensively used by the US Air Force for their projects. LabVIEW enables programming by implementing directly the equivalent of an SADT "actigram". Apart from this academic aspect, LabVIEW can be used in a variety of forms, creating projects that can spread over an enormous field of applications: from control and monitoring software to data treatment and archiving; from modeling to instrument control; from real time programming to advanced analysis tools with very powerful mathematical algorithms ready to use; from full integration with native hardware (by National Instruments) to an easy implementation of drivers for third party hardware. In this book a collection of applications covering a wide range of possibilities is presented. We go from simple or distributed control software to modeling done in LabVIEW; from very specific applications to usage in the educational environment.

How to reference

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