

# INTEGRATION OF THE BOOSTER SYNCHROTRON CONTROL SYSTEM TO THE SPRING-8 CONTROL SYSTEM

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## Abstract

The integration of the booster synchrotron control system to the SPring-8 control system finished successfully in January 1999. This integration allows us to operate the synchrotron, the beam transport line and the storage ring in a seamless fashion.

## 1 INTRODUCTION

At the SPring-8 accelerator complex, there are a 1 GeV linac, a booster synchrotron and an 8 GeV storage ring. The synchrotron accelerates electron beams from 1 GeV to 8 GeV with the repetition rate of 1 Hz [1]. We started the beam commissioning of the synchrotron in December 1996 [2]. Before starting the commissioning, the control system of the synchrotron was constructed independently from those of the other accelerators [3]. The synchrotron control system consisted of the systems of the synchrotron and the beam transport line to the storage ring. This control system was able to accomplish the synchrotron commissioning.

However, a more tight integration of the control systems of the synchrotron and the storage ring was requested for the future developments and seamless operation. It was decided to integrate the synchrotron control system with the SPring-8 standard control system.

## 2 POLICY OF INTEGRATION

Since October 1997, experiments by synchrotron radiation (SR) users started with the highest priority. We gave attention to keep user time during the development and test of the new system.

We used the control system framework which was developed initially for the storage ring [4]. Because this framework was adopted not only for the storage ring but also the SR beamlines and the New SUBARU storage ring [5]. It is now the standard SPring-8 control system.

Equipment specialists developed the low level software (Equipment Manager, EM [6]) and the high level graphical user interface software as well. It was suitable for the specialists to extract the full capability of the equipment.

Modification of the front-end hardware was minimized because the hardware system was almost satisfactory. This reduced the task of integration and the task member could focus most of his time on the software developments.

## 3 HARDWARE MODIFICATION

For the front-end control, 14 VMEbus systems controlled by MVME 147SA-1 Motorola CPUs were distributed in 7 power-supply rooms and 5 monitor rooms. Additionally, remote I/O fieldbus sub-systems such as NIO, MTC/UDC, GP-IB and RS-232C serial port were used [7]. We only changed the CPU boards from MVME147SA-1 to the HP9000/743rt that was used in the SPring-8 control system. It was essential to replace the CPU boards to install the standard software framework. However, other hardware sub-systems and I/O boards were left unchanged.

In the original system, a DEC4100/5/466 with 2 CPUs was used as the host computer. Two DEC3000/300X and two Alphastation255/233 were used as the operator consoles. These workstations were replaced by the HP9000/B180 series as the new operator consoles. File server and database functions were integrated to the servers used at the SPring-8 control system.

The network system was changed from coaxial yellow cable in shared topology to optical fibers with Ethernet switching hubs in star topology. The hubs were directly connected to the FDDI backbone. Thus, the CPUs on the VMEbus system were linked to the backbone FDDI fiber network with better performance [8].

## 4 SOFTWARE SYSTEM

### 4.1 Framework

Corresponding to the replacement of the CPU boards and the operator consoles, we changed the lower level operating system from OS-9 to HP-RT and the higher level one from OpenVMS to HP-UX.

The control software was divided into the basic framework part and the application part. The former was already developed and applied. By using this framework, we could control the equipment of the synchrotron and the storage ring with the same software scheme as we expected.

The VME front-end control software (EM) was newly developed on HP-RT by the equipment specialists. The X11-based application software, like the operation window software (GUI), was developed on the HP-UX operating system as well.

### 4.2 Device driver

The device drivers for some VME boards were already prepared [9]. Because we retained most of the VME I/O boards without change, we had to develop eight device

drivers based on HP-RT for example NIO, MTC/UDC, RS-232C and so on.

### 4.3 Database

The SPring-8 control system fully depends on a database system which is managed by a relational database system, Sybase Adaptive Server Enterprise 11 [10].

All operational parameters of the equipment were stored in this database. The synchrotron had 1173 device objects in the database.

In order to monitor equipment operational values and status, the data were stored periodically to the database by poller/collector software [11]. The number of data items from the synchrotron managed by the database was 1542. We managed all data with the same database system in a uniform way and we could access the data using the same procedures.

### 4.4 Alarm

A hard-wired interlock system protects the equipment. The status of the interlock was monitored by the alarm system and any failures logged into the database [12]. The diagnostics software with alarm surveillance and a display system was newly installed in the system.

### 4.5 GUI

The operation's windows were also newly created with a new configuration. Specialists developed the X11 window software using the GUI builder X-Mate [4].

## 5 CONSTRUCTION

### 5.1 Process

The construction process is listed as follows:

- List the operational commands and the monitored points for the equipment of the synchrotron.
- Analyze the control sequence and design the operation's windows.
- Define the SVOC commands which are the messages to control the devices.
- Program the EM functions for the translation of SVOC commands to drive VME I/O boards.
- Test the EM functions by simulating the device on the HP-UX machine.
- Test the EM functions on the VME by using the real equipment.
- Create the operation's windows by using X-Mate.
- Program the call-back routine functions of the windows programs. The message communication codes, such as sending the SVOC commands or receiving replies from the EM, are included here.
- Test the operation's windows.

In the early stage of the developments, we tested the system using the real equipment during the machine stop period. This period was from Friday evening to Tuesday noon once every 3 weeks of the beam operational cycle. However, test time was not sufficient to fix the system afterwards. We usually injected electron beams to the storage ring once a day. After the beam injection, we could spend the rest of the time testing the new system. The changes to the new system and backup of the old system were achieved by replacing the 14 VME CPU boards only. This allowed us to test the new system every day before the winter shutdown.

### 5.2 Operation's windows

With the advantage of experience of the real accelerator operation, we reanalyzed and reconfigured the operational sequence to achieve optimal operation. For example, the main window of the synchrotron control system can be seen in Figure 1.

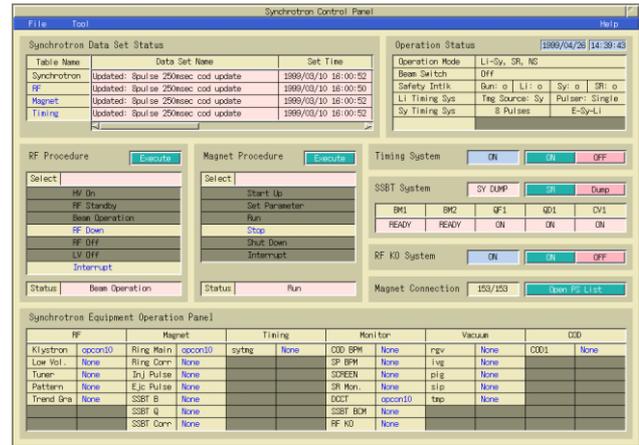


Figure 1: Synchrotron control system main window.

We configured the standard operation commands within this window. For the RF system, the operational procedures consist of 6 functions. In the new system, we can increase the acceleration voltage from the klystron cold state to the beam operation state using only 3 procedures. For all of the 153 magnet power supplies of the synchrotron, we could operate all the magnets together using a smaller number of procedures. The beam transport mode either to the storage ring or to the synchrotron beam dump could be changed easily. Whenever the single bunch beam was required, a mode change was achieved by just turning on the RF-KO system [2].

The main window was designed to launch the equipment primitive windows for the fine tuning of equipment.

### 5.3 Cavity voltage control

We have two klystrons each providing power to four cavities. During the ramp up of the beam energy from 1 GeV to 8 GeV, the acceleration voltage increase from 2 MV to 18.6

MV. We are controlling the effective acceleration voltage by changing the rf phase between cavities, while keeping the rf voltage of the cavities constant.

To set the cavity voltage, we used Equipment Manager Agent (EMA) processes [13]. These processes work to increase or decrease the cavity voltage by monitoring the cavity vacuum pressure. We monitored the EMA working status on-line using the window as shown in Figure 2.

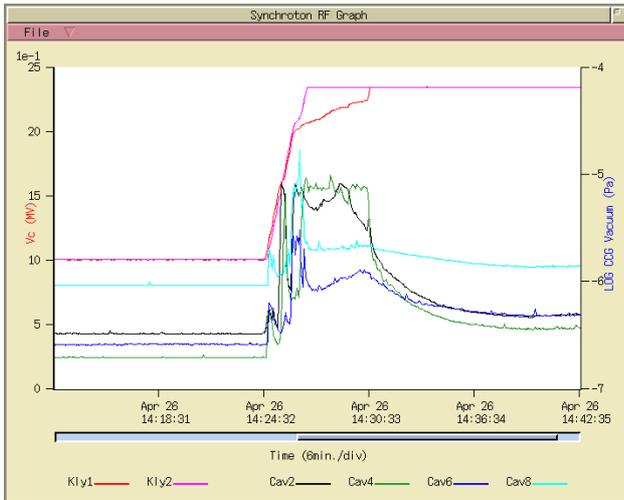


Figure 2: RF cavity voltage and vacuum pressure monitoring window.

### 5.4 Ramping pattern control

Figure 3 shows the editor window of the acceleration voltage ramping pattern. We can select the interpolation methods between set points to either linear line or 3rd order spline. The phase pattern between cavities is generated using a Toshiba PMEM board with a resolution of 180 degree / 10 bits using a 10 kHz clock.

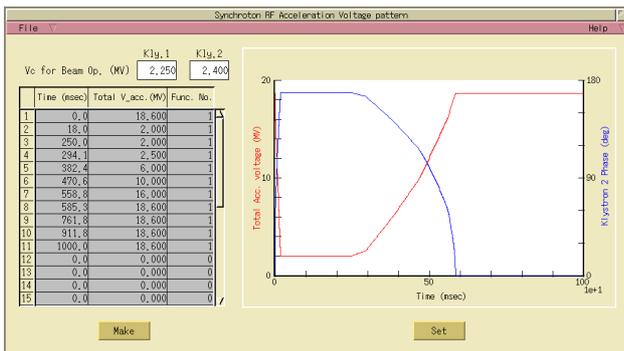


Figure 3: RF acceleration voltage ramping pattern editor window.

The power supplies for the main magnets (BM, QF, QD, SF and SD) are also operated by 1 Hz ramping patterns. To generate the patterns, we are using 9 MTT MVME-56000-0 FDO boards with a 10 kHz clock. The scale factor of

currents are 1500 A / 18 bits for BM, 535 A / 18 bits for QF, QD and 400 A / 16 bits for SF, SD. The editor window, as with the RF case, can set these ramping patterns. Furthermore, we can choose a pattern generator by specifying 3 parameters; a current for injection, a current for extraction and a delay time to start the pattern. This is useful to adjust the betatron tune.

## 6 CONCLUSION

The integration of the synchrotron control system to the SPring-8 control system was successful. The analysis of the machine parameters between the synchrotron and the storage ring became easier by utilizing the data saved within the same database. The integration reduces the manpower and improves the cost efficiency for future maintenance and improvements.

## 7 REFERENCES

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