UPGRADE OF RF CONTROL SYSTEM AT SPRING-8

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Abstract

SPring-8 has been operational for over 10 years. Recently, we encountered the need to replace the conventional commercial I/O boards since their manufacture had been discontinued. Further, the previously installed GPIB control system caused instabilities in the control system. Therefore, we replaced the conventional I/O boards for the SPring-8 RF control system. The replacement of the large number of boards, which operates a large number of signals, requires a lot of time, which is not feasible due to the short shutdown period of the accelerator operation. To solve this problem, we developed two new boards – an analog input (AI) board and pulse train generator (PTG) board. The new boards were designed to have the same signal cabling scheme and software application as the current system. In addition, additional improvements (higher signal density, better resolution for AI, and flexible logic with logic-reconfigurable VME board for PTG) were introduced at the same time. Approximately 40 AI boards were successfully replaced in a short period. Furthermore, we achieved better resolution after AD conversion and the number of boards reduced. For GPIB control, we used a small embedded computer (Armadillo) instead of the RS-232C-GPIB converter. Thus, we were able to improve the stability of the RF control system.

INTRODUCTION

SPring-8 is the largest third-generation synchrotron radiation facility in the world, and it has been operational since 1997. To maintain optimal performance over a long duration, it is important that the reliability, stability, and flexibility of the control system be maximized.

In this paper, we report on a recent upgrade of the RF control system for the accelerator storage ring at SPring-8. Most of the control systems for the storage ring were implemented during the early stages of construction, and the manufacture of some commercial I/O boards used in the RF control system has already been discontinued. In addition, it was observed that some parts of the GPIB control system caused instabilities.

To solve this problem, we developed a new analog input (AI) board, and a pulse train generator (PTG) board, and utilized a small embedded computer (Armadillo). The replacement of the AI board in the SPring-8 RF control system with the newly developed ones is already complete.

Herein, we provide a brief introduction of the RF control system. We thereafter describe the development and replacement of the AI board, the development of the PTG boards, and the replacement of the GPIB control system.

RF CONTROL SYSTEM AT SPRING-8

The role of the RF control system is to provide accelerating voltage and power to compensate the energy loss of the electron beam in the SPring-8 storage ring. Details of the RF system can be found in [1]. Four RF stations (A, B, C, D) are symmetrically arranged around the storage ring. The klystron, low-level equipments, and RF cavities in each station are controlled.

All of these controls are performed by a VME system with the MADOCA control framework [2]. For low-level control, NIM modules specific to the SPring-8 RF are used, but these NIM modules are controlled by a computer network system with VME. For this control, many VME boards are used for AI, digital input (DI), digital output (DO), PTG, and GPIB. The GPIB is used to control of flow and temperature of cooling water, vacuum in the RF cavities. The numbers of control signals for each RF station are shown in Table 1. It can be observed that the numbers of control signals for the RF system is quite large.

Table 1: Numbers of Control Signals for Each RF Station

Type of Signals	Number of Signals
AI	~170
DI	~150
DO	~60
PTG	~30
GPIB	~170

The conventional AI boards have been known to have occasional malfunction. We thus developed AI and PTG boards to replace conventional I/O boards. In the case of GPIB control, about 60 signals out of the ~170 signals use the RS-422 interface. To control many such signals with a VME-based GPIB board, we used the RS-422-RS-232C and RS-232C-GPIB converters. However, we sometimes detected communication errors due to bad compatibility between the RS-232C-GPIB converter and the GPIB-VME board. Thus a more reliable GPIB control system is required.

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DEVELOPMENT AND REPLACEMENT OF ANALOG INPUT BOARDS

We used the AVME9325 board (Acromag Inc.) as the AI board in the RF control system before the upgrade. In all, 43 AI boards were used due to the large number of signals, as shown in Table 1. This AI board had many excellent features such as programmable gains, several trigger modes and RAM storage. However, because these boards were reported to malfunction occasionally and their manufacturing was consequently discontinued, we had to replace these boards. Such replacements need to be performed within a short shutdown period of the accelerator operation.

To facilitate smooth replacement of the boards, we attempted to retain as much of the original peripheral hardware as possible and we tried to avoid changing the software application.

The newly developed AI board, Advme2618 (Advanet Inc.), is shown in Figure 1. The specifications of the board are described below.

- 16(64) differential or 32(64) single-ended inputs for VME bus-P2 side (VME front side)
- 10 μs/channel throughput rates (for sequential channel scanning)
- 16-bit A/D resolution
- Several programmable input ranges: ± 10V, ± 5V, ± 2.5V, ± 1.25V, 0~10 V, 0~5 V, 0~2.5 V, 0~1.25 V
- 128 kB of dual port RAM capable of storing 64k data samples
- Two types of data acquisition modes (continuous and block mode)
- Three trigger sources (external, software, internal timer)

The new board was designed to have similar functional features (programmable gains, trigger modes etc.) as the older boards. Further, using the VME bus-P2 side as the analog signal input port, it was possible to have the same cabling scheme as the original.* In addition, software applications similar to conventional ones can run the new boards. Thus, the replacement of AI boards can be performed easily.

At the same time, the new board has been designed to have some additional improvements. They are as follows.

- A/D resolution is improved from 12-bit to 16-bit.
- Input impedance is reduced from 5 GΩ to 1 MΩ. We used an impedance conversion board to reduce the input impedance. We don't use such additional conversion board for the new AI board.
- A higher signal density can be achieved if the analog signals are inputted from VME front side.

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* The new board was also designed as a replacement for the VMIVME-3122 board (VMIC Inc.) used at the SPring-8 beam line control. The signal cabling scheme of the analog signal inputs from VME front side was adjusted to be same with VMIVME-3122.

For the upgrade of the RF control system, all 43 AI boards were successfully replaced without problems within short shut down periods of accelerator operation in the summer and winter of last year. The new AI boards are working fine, as expected.

For the RF station A, we changed the signal cabling inputs from the VME bus-P2 side to the VME front side by using conversion card. Due to the high signal density, the number of AI boards could be reduced from 10 to 6. For further reduction in the number of AI boards, we plan to change the signal cabling inputs to the VME front side for the other RF stations as well in the near future.

Figure 1: Developed AI board, Advme2618.

DEVELOPMENT OF PTG BOARDS

In an RF control system, a PTG board is used to control the analog output voltage supplied to the low-level equipments. The MP0351 board (Micro Craft Inc.) has been used as the PTG board. CW/CCW pulses from MP0351 were used to adjust analog output voltage. Pulses from PTG are amplified by a buffer amplifier, and then sent to a specific NIM module, the up/down module 8616/N (Clear Pulse Inc.) which outputs the analog signals. One PTG board can handle 5 CW/CCW outputs. To control 30 signals, 6 boards were used in each RF station.

Since the older PTG boards were discontinued, we had to design new PTG boards. We intended to design a board that would facilitate smooth replacement of the older boards and that would have additional improvements over the older boards. Herein, we provide a brief description of the new PTG board design.

For the upgrade of the PTG boards, we selected a logic-reconfigurable VME board (Axvme4900, ARKUS Inc.) [3]. The Axvme4900 can mount two I/O daughter boards and its logic can be designed with an on-board field programmable gate array (FPGA). Owing to its flexibility, this board has several applications (PID feedback system, screen monitor system with camera link interface, shutter controller [4] etc.) at SPring-8. Since the logic of PTG is simple, we can easily design a new PTG with Axvme4900. The new PTG will have new DO boards with 30 channels of outputs as the daughter boards. The new PTG board can handle 30 CW/CCW outputs. In addition, the buffer amplifier will be replaced with one

that is specific to the new PTG. With the new system, the number of PTG boards can be reduced from 6 to 1 for each RF station. Further, the same signal cabling can be used for the inputs to the buffer amplifier. With a similar software application, the PTG system will be smoothly replaced, as in the case of the AI system.

REPLACEMENT OF GPIB CONTROL SYSTEM

The GPIB interface controls the flow and temperature of the cooling water and the vacuum of the RF cavities. As described above, the GPIB control for RS-232C was unstable due to bad compatibility between RS-232C-GPIB converter and the VME-based GPIB board. Due to these instabilities, we could not measure the data related to the RF cavities over a long-term period.

For the replacement of the GPIB control for RS-232C, a small embedded computer, Armadillo-220 (Atmark Techno Inc.) [5] was used as the RS-232C-Ethernet converter. Armadillo-220, shown in Figure 2, is a compact computer running LINUX OS and powered by PoE. Armadillo-220 is controlled by the existing VME using TCP/IP socket communication.

Not only Armadillo-220 is compact in size, but it also has high reliability and flexibility. We have already developed several other applications involving Armadillo-220 for our control system. The detail can be found in [6]. For example, we used Armadillo to control the programmable logic control of the linac modulator by embedding the MADOCA control system. We also used Armadillo as a voice talker system by running the server program.

We replaced GPIB control for RS-232C control with control system using Armadillo last year without problems. As a result, the stability of our control system increased, and we faced no problems related to communication errors.
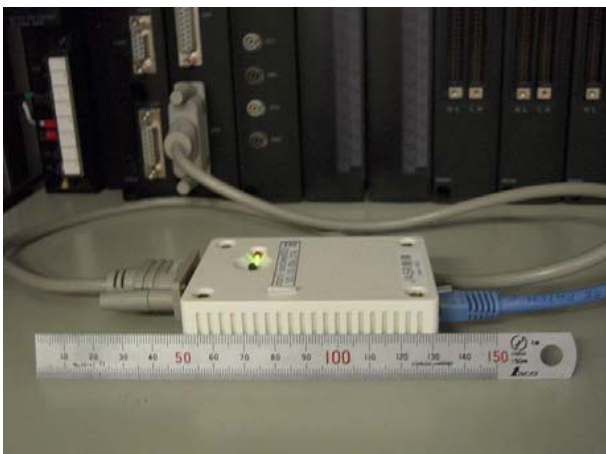

Figure 2: Armadillo-220.

SUMMARY

In this paper, we described the recent upgrade of the RF control system at SPring-8. Some I/O boards in the accelerator control system had to be replaced since their manufacturing had been discontinued. Replacement in short accelerator shutdown period is difficult because the system includes many I/O boards with a large number of signals. To solve this problem and to facilitate smooth replacement, we developed new I/O boards. Our approach was to increase the performance of boards while maintain their original structure (same cabling scheme, similar software application etc.). This approach was successful for the upgrade of our control system. 43 AI boards were smoothly replaced without any problems, and some functions were improved (e.g. high signal densities). Here, it should be mentioned that efforts to increase the stability of our control system are underway. The GPIB controls for RS-232C, which caused instabilities, were successfully replaced with a reliable control system containing a small embedded computer, Armadillo.

ACKOWLEDGEMENT

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