WEAP014

SYNCHROTRON CONTROL SYSTEM OF HIMAC

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Abstract

HIMAC, Heavy Ion Medical Accelerator in Chiba, has been in operation for about 8 years. The control system of HIMAC synchrotron is now undergoing renewal and upgrade. As a medical accelerator in use, reliability and availability of the beam must not be compromised in HIMAC. We decided to change most computers of the system in a node-by-node way, over a couple of years. Among the replaced are: Power-supply Controllers, RF-system controller, Beam Transport, and Timing System controllers. The steps taken and to be taken are reported.

1 INTRODUCTION

HIMAC accelerator complex has successfully provided carbon beam for clinical study on the cancer treatment since June 1994; cumulated number of patients treated by irradiation of HIMAC carbon beam exceeds one thousand in July, 2001 [1]. It leads to the planning and realization of a few particle therapy facilities in Japan [2].

HIMAC accelerator complex has been required to supply ion beams, not only for an ion therapy, but also for wider range of biological and physics experiment using various ions from H to Xe. As such, synchrotron control system has to meet needs of developing and tuning new beams, which becomes harder and more complicated than the original scheme had assumed. Initial design of the system was reported in the earlier conference of the series [3].

2 HARDWARE REPLACEMENTS

The figure on the last page of the report shows the present configuration of the HIMAC synchrotron control system. Relevant elements are described in the following.

2.1 Operation Terminals with Touch Panel

As reported in the last conference for injector linac system, the terminals in synchrotron control system were also replaced by PC's, and their performance is satisfactory [4]. (The problem mentioned there turned out to be a bug in OS.)

2.2 Power supply Controllers

Power supplies for synchrotron magnets were grouped and controlled by VME-bus board-computers for trapezoidal pattern cycle. The cpu board of the controllers had been VME147 and were replaced by VME162 in a similar situation as in the operation terminals. It is also planned to upgrade further with a Power PC family board.

The installation of DPI/O and DTO boards [5] are now under way.

2.3 PLC for power supply status control

Operational status (ON/OFF, Faults, and interlocks) of power supplies were controlled and monitored by a dedicated PLC, HIDIC-S10α, made by HITACHI. We have added a gateway PC in order to provide an additional access to the PLC from the independent system other than the original control main computer.

2.4 RF pattern memory control

The RF acceleration voltage, frequency curve, and ferrite-bias current must be controlled in accordance with the main magnet excitation. Another VME computer was prepared to facilitate the function, and was called RF pattern memory. It was, however, connected via GPIB to the FA computer (Toshiba, G200E), which then communicated with the main computer of the system, and took care of RF power and ring vacuum devices as well, in the beginning. At the occasion of the replacement, we have separated the RF pattern memory and connected it directly to the synchrotron control LAN.

2.5 PLC for RF power and vacuum control

As mentioned above, event-critical part of the function of the FA computer was separated and the rest of the functions can be carried out by a PLC reasonably. Therefore, the former was replaced by the PLC with LAN interface.

2.6 PLC for Beam lines into and out of the ring

Beam transport lines of injection and extraction regions were also controlled by the FA computer as for

RF system. Although the number of I/O points is larger in BT case and BPM data processing demands faster cycle than, e.g., vacuum data monitoring, it is still the case that PLC can perform the control function. Thus the replacement is under way for both upper and lower rings.

3 ADDITION OF NEW CONTROLLERS

There are devices that have not been foreseen but added after the commission of the machine. RF-KO system for beam intensity control, and Electron Cooling system (for the lower ring only) are among them.

3.1 Electron Cooling System

At present, the electron cooler is installed and used for accelerator study in the lower ring. Its control system is independent from the main system to avoid possible interference with routine therapy operation. However, once the EC operation procedure is established and incorporated into future treatment irradiation, the control system will also be merged into the main system.

3.2 Beam Intensity Controller

Beam intensity control by applying lateral RFKO field at injection energy level as well as flat top has been developed and constructed for both therapeutical respiration gating and experimental study of radiobiological irradiation. The system will replace the present RFKO system for respiration-synchronizing gate.

4 SOFTWARE ENHANCEMENT

Synchrotron rings deliver carbon beams for cancer therapy, at present, of 290, 350, and 400 MeV/u. In order to help increase total throughput of treatment, and to help reduce the load of daily operation, a few enhancement of operational tools has been done.

4.1 Energy Changing Sequence

Accumulated experience established the energy changing procedure for treatment condition where the reproducibility of beam is well observed. The original procedure provided many adjustable parameters and took time and cautious tuning on the part of operators. With the adoptation of established procedure into the control sequence, the time needed for the change has become about 5 minutes, reduced to nearly a quarter of the previous condition. An extension of similar trimming of the procedure for injection part is now in preparation.

4.2 Demagetization Sequence

In the COD correction, excitation of the steering magnets (STV and STH, for short) may differ with different beams, such as for the therapy use beam and one for cooling study. The residual magnetic field of the STVs, e,g., however, can be problematic since it causes occasional intensity decrease. It was nullified by de-magnetizing the STVs as expected, but the procedure was tedious and time-consuming. Therefore, the procedure was made into the sequence from the main computer, and an operator can now conduct it by simple cell-touch. The enhancement contributed to keep the beam intensity level for treatment with comfortable margin.

4.3 Parameter-Editing Station

Operational parameters were stored in the database, which was supposed to be accessible only from the control stations. As the machine was providing beams to the users continuously, it was found that the preparation and/or review of parameters through the operator console is inconvenient. Therefore, an addition of extra workstation for parameter editing and relevant tools was done. Since the tools were basically common to the existing one at console, and with handy enhancement such as comparing two files of any rings, it proved fruitful for operational improvement.

5 FARTHER PLAN

The replacement of present main computer, VAX4000/300, has been considered, both because of increased load from new devices and operations and because of aging hardware. To succeed existing software application with least extra work and most reliability, we picked an Alpha system of the same manufacturer as for the old one. Performance comparison of the new and old system was carried out. Typical result shows the following (for starting-up of the application system memory):

Alpha XP900	3.46 sec. (average)
VAX4000/300	156.35 sec. (average)

The result suggests a major improvement in terms of the response time of the system to the operator action. We now plan to replace the old VAX4000 by the new machine in next March.

The static VAR compensator (SVC) will need closer control to use cooled beam, which is under study. The backbone for the synchrotron control should be upgraded for faster multi-path one from the present 10BASE5.

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REFERENCES

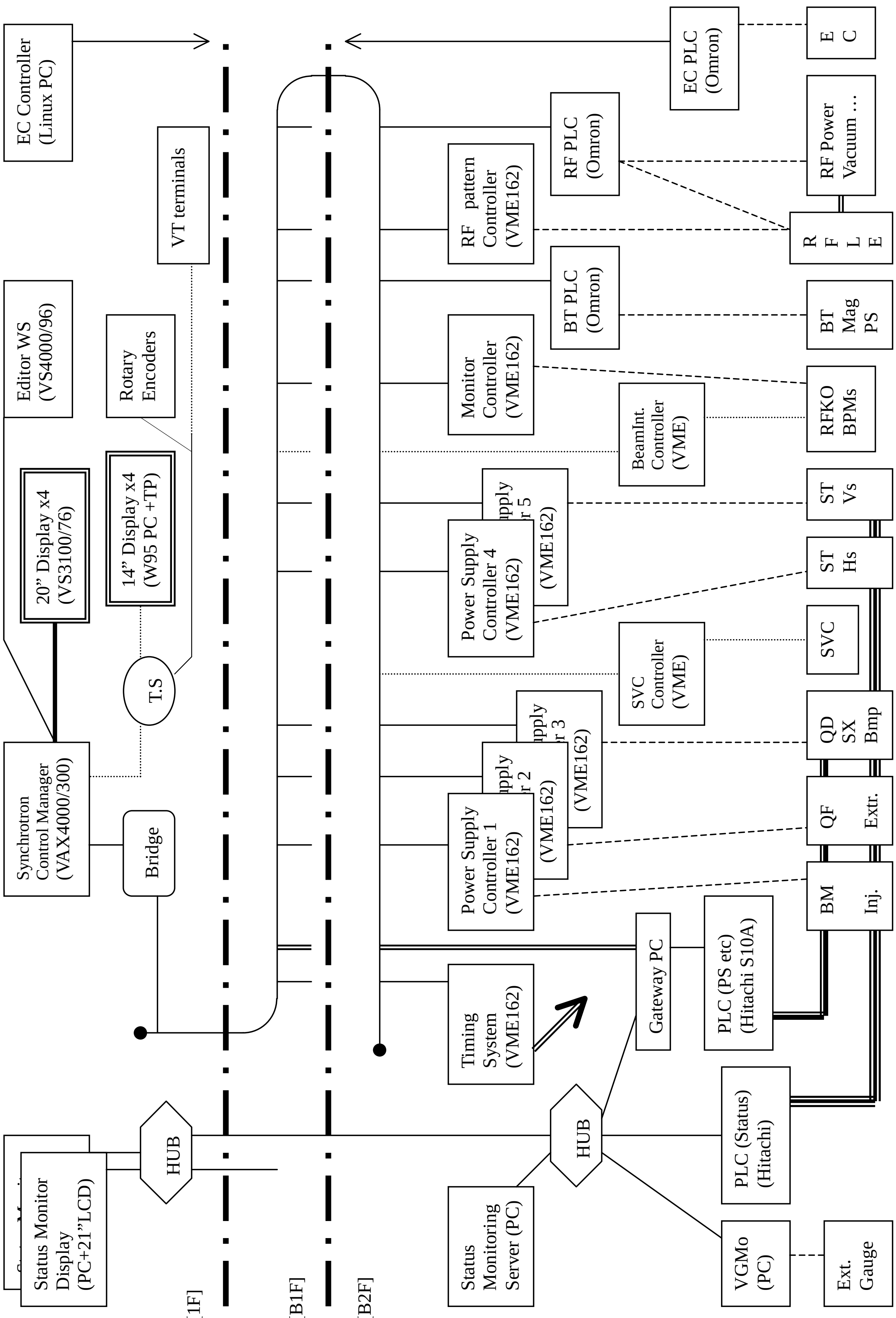
[1] E. Takada *et al*., "Present Status of HIMAC", pp. 187-189, Proc. of SAST'01, Osaka, October 2001. C. Kobayashi et al., "Operation of HIMAC and cancer therapy", pp. 214-219, Proc. of WAO2001, CERN-2001-002.

[2] S. Yamada *et al*., "HIMAC and Medical Accelerator Projects in Japan", APAC'01, Beijing, September 2001.

[3] E. Takada *et al*., "The HIMAC synchrotron control system", Nucl. Instr. & Meth. A352, 40-42 (1994).

[4] E. Takada *et al*., "Present status of control systems of HIMAC accelerator complex", pp. 683-685, Proc. of ICALEPCS'99, Trieste, 1999.

[5] N. Araki *et al*., "Design of a Synchrotron Control System with DPO Series for Advanced Therapy Operations", T3B-6, ID157, Proc. of ICALEPCS'97, Beijing, 1997.


EC Controller (Linux PC)
VT terminals
Editor WS (VS4000/96)
Rotary Encoders
20" Display x4 (VS3100/76)
14" Display x4 (W95 PC +TP)
T.S
Synchrotron Control Manager (VAX4000/300)
Bridge
HUB
Status Monitor Display (PC+21"LCD)
[1F]
[B1F]
[B2F]
EC PLC (Omron)
E C
RF PLC (Omron)
RF Power Vacuum …
RF pattern Controller (VME162)
R F L E
BT PLC (Omron)
BT Mag PS
Monitor Controller (VME162)
BeamInt. Controller (VME)
RFKO BPMs
ST Vs
ST Hs
Power Supply Controller 4 (VME162)
(VME162)
SVC
SVC Controller (VME)
QD SX Bmp
QF Extr.
BM Inj.
Power Supply Controller 1 (VME162)
Gateway PC
PLC (PS etc) (Hitachi S10A)
Timing System (VME162)
HUB
PLC (Status) (Hitachi)
Status Monitoring Server (PC)
VGMo (PC)
Ext. Gauge