The Accelerator Control System for the Hyogo Hadrontherpy Center

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Abstract

A change in the amount of synchrotron energy is required in the Accelerator Control System for the Hyogo Hadrontherpy Center*2 to accommodate future raster scans and voxel scans. In addition, to maintain treatment time, a reduction in energy and nucleide change time is also required. In the past, the accelerator control system was comprised of VME (Versa Module Europa) computers and EWS (Engineering Work Station) units. By applying the optimum control method to each system feature, however, a high-performance accelerator control system comprising a combination of VME computers, decentralized controllers, PLC (Programmable Logic Controller) units, and PC (Personal Computer) units is achieved.

I Introduction

In the past, EWS units were used as the MMI (Man-Machine Interface) owing to the extremely large difference in EWS and PC performance. In addition, high-performance VME computers were used as the controllers and, to reduce the amount of cables in the input/output area, RIO (Remote Input Output) units and UDC*3 (Unit Device Controller) units were also used.

The Accelerator Control System for the Hyogo Hadrontherpy Center should have high-speed response in order to change output energy of synchrotron every pulse. Furthermore, the accelerator is used in the medical field that requires high reliability and maintainability in addition to high performance. Owing to these demands, technical research was conducted without adhering to conventional designs, and the control system was rebuilt. The performance capabilities required in this system are shown in Table 1.

II System Configuration

The Accelerator Control System is divided into 3 groups;man-machine interface, the controller, and the network.
The features of each equipmennt is described below.

Table 1 Performance Capabilities Required in the Accelerator Control System

Response Times	
• Data Update Cycle in MMI	1 sec (average)
• Change Command of the Electromagnetic Power-Source Current (from the time in which the energy change command is output from the irradiation system to the time in which the current command of the electromagnetic power source is output)	40 msec
• Pattern Data (2 Mbyte) Load Time (During pattern data loading, the effect on the control/monitor response time is to be minimized.)	1min

II.A Man-Machine Interface

Due to recent innovations in technology, there have been remarkable improvements in PC performance that have greatly reduced the EWS and PC performance gap. In addition, the PC has an abundance of general-purpose software and is superior to the EWS in ease-of-use.

For these reasons, the decision was made to use a PC as the man-machine interface. The PC used is a PC/AT unit which conforms to defacto standards; to facilitate 24-hour continual operation, unique server units were used for machines monitoring and controlling all systems and industrial PC units were used for all other machines.

II.B Controller

Proposed controllers include the VME computer and the PLC unit. Each of these has advantages and disadvantages; to configure all of the control units using identical components, therefore, is considered unwise. Consequently, the VME computer or PLC unit was applied to each control unit using the policies described below.

PLC : control units that demand reliability but have simple logic

VME : control units that demand high-speed computation and control units that have special interface with equipments and hence already have an interface board provided

The specific configuration of the controller is described below.

(1) The controller is divided into 3 division (Injection System, Synchrotron System, HEBT System). A general control system that is configured using a PLC unit is arranged in each division. The control of the power switch, etc., of the equipment in a system is performed by the corresponding general control system. In this way, equipment can be safely shutdown even when a VME computer fault occurs.

(2) Since the controller of the Injection System Equipment has nothing to do with the energy change per pulse, a VME computer, which have had positive results in HIMAC*[1] (Heavy Ions Medical Accelerator in Chiba), is applied. UDC (Unit Device Controller) units is used as the equipment interface.

(3) VME computers and pattern memory that has been effective in HIMAC are used in the Synchrotron Electromagnetic Power Source / RF Pattern Control and the Timing System.

(4) PLC units are used for the control and monitoring of Vacuum System Equipment and Profile Monitor Related Equipment.

(5) PLC units are used throughout the HEBT System since the system mainly involves DC power-source control.

(6) A decentralized local controller which can be incorporated into equipment is used as the DC power-source interface. By incorporating the controller in the power-source unit, a great reduction in the number of exterior cables and control panels is achieved. The local controller is used to diagnose the power output through electromagnet initialization, current configuration value, and current monitor value comparisons thereby lightening the load of upper level PLC units.

(7) Energy change signals for each pulse are input in Irradiation System I/F PLC units provided in the Synchrotron and HEBT Systems. These signals, via a network from the Irradiation System I/F PLC units, change the current for the local controller. By establishing these PLC units separated from the General Control System, response capabilities are maintained.

(8) Energy change signals to pattern memory are input in the TS (Timing System). These signals change pattern memory using hard-wired signals from the TS to the Pattern Control VME. As a result, response capabilities are maintained.

II.C Network

Various networks could have been used in the system. As a component that connects the MMI and the controller, however, the networks selected are ones that are highly compatible with the MMI and the controller and that satisfy required response times. Therefore, with the VME computers and PLC units functioning as the controller, the Ethernet is applied as the MMI-VME computer interface and a PLC network is applied as the MMI-PLC interface.

The merits of each network are described below.

Ethernet: Although high-speed, communication protocols are manifested by software thereby increasing the CPU load. Fixed periodicity cannot be guaranteed since response time varies depending on the network load.

PLC Network: High-speed; communication protocols are performed by hardware or communication interface firmware thereby not increasing the CPU load. The communication method is a token passing method and hence fixed periodicity is guaranteed.

The specific configuration is described below.

(1) Data that are sent intermittently in great amounts such as pattern data are transmitted by Ethernet.

(2) Equipment operation and equipment monitoring signals are transmitted by the PLC network. As a result, a reduction in MMI CPU load and a safer control and monitoring process are achieved.

(3) In the PLC-VME computer network, connection is achieved using a serial I/O bus that has been successful in HIMAC, and the VME control and monitoring signals are also transmitted using the PLC network.

The serial I/O bus manifests all communication protocols using hardware and performs data transmission with the controller using shared memory. Since the controller can receive data by simply reading and writing in shared memory, there is no increase in controller load.

II.D Overall Configuration

The Accelerator Control System for the Hyogo Hadrontherpy Center is shown in Figure 1

In the conventional HIMAC system, the controller was mainly comprised of VME computers. This control system, however, was designed to use PLC units and local controllers in simple control sections having DC power sources, etc., and hence exhibits an increase in reliability.

In addition, contrast to conventional systems that mainly use Ethernet networks, this control system uses Ethernet as the information network and a PLC network as the control and monitoring network thereby achieving an increase in the reliability of operation-monitoring.

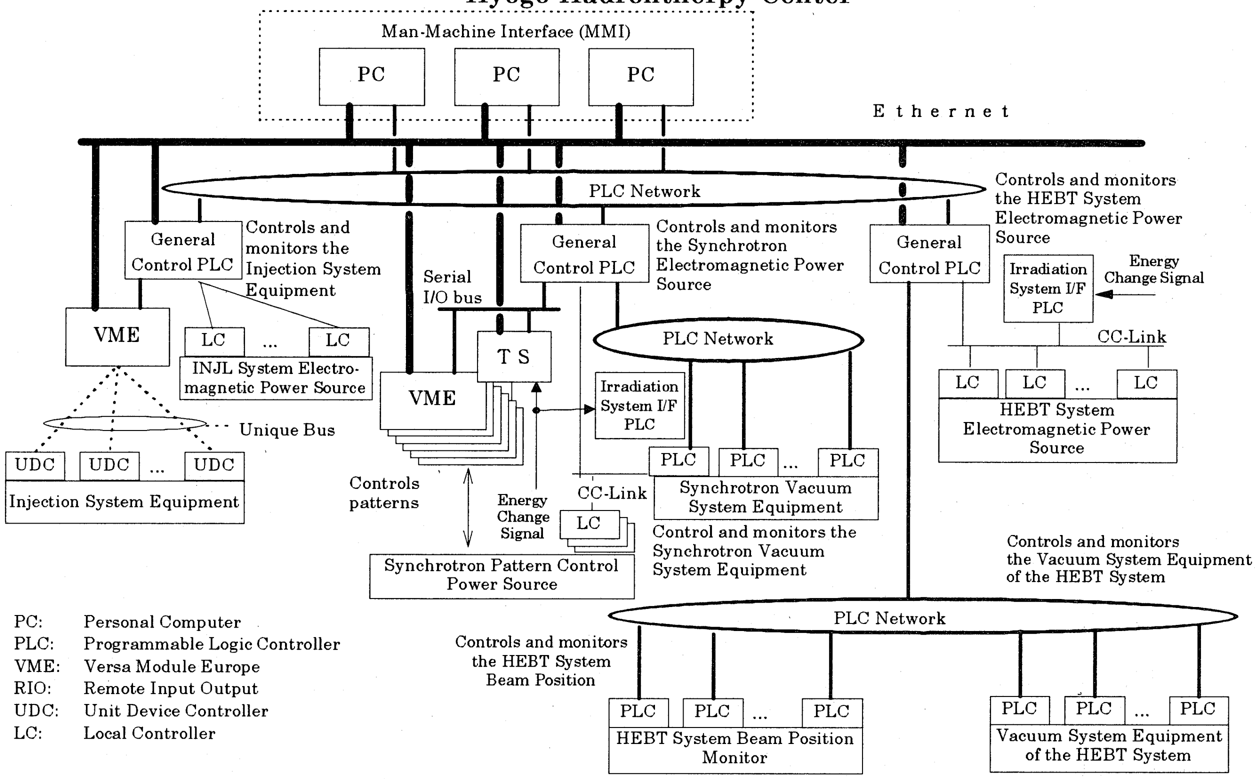
III Conclusion

Through the above-described system configuration, a system is achieved that is highly reliable as a control system for accelerators used in the medical field.

This system is now currently (in August) under testing at the plant to confirm that a desired response performance is attained.

The target date for completion of the Accelerator Control System for the Hyogo Hadrontherpy Center is December, 2000. On-site conditioning tests, therefore, are scheduled to begin in November.

Figure 1 The Accelerator Control System for the Hyogo Hadrontherpy Center



Reference

[1] Proc. of NIRS International Seminar on the Application of Heavy Ion Accelerator to Radiation Therapy of Cancer in connection with XXI PTCOG Meeting, Nov. 14-16, 1994, Editor T. Kanai and E.Takada, NIRS-M-103 (HIMAC-008).

[2] A.Itano et al., Hyogo Hadrontherapy Centre Project, Proc. of the Second International Symposium on Hadrontherapy, PSI and CERN, Switzerland, 9-13 September 1966 ; 1997 Elsevier Science B.V., pp.193 - 196.

*1 HIMAC (Heavy Ions Medical Accelerator in Chiba): A heavy ion accelerator used for medical treatment in the National Institute of Radiological Sciences in Chiba Prefecture. The accelerator has 3 stationary treatment rooms and 1 irradication room for physical and biomedical research. (Completed April, 1994.)

*2 Hyogo Hadrontherpy Center: An ion beam accelerator to be used for medical treatment; currently under development by Hyogo Prefecture in Harima Science Garden City. The accelerator has 3 stationary treatment rooms and 2 rotating-gantry treatment rooms (used for proton beams only). (To be completed December, 2000.)

*3 UDC (Unit Device Controller): A controller that is built into equipment, equipped with a CPU, and designed to have control features. A UDC is connected to an upper level controller (VME computer) by a unique network.

*4 CC-Link (Control & Communication Link): A master-slave PLC network disclosed to the public having a lower layer transmission speed of 10 MBPS; the maximum number of connected stations is 42. The transmission medium is an optical cable or a twisted pair line.

*5 Serial I/O Bus: A master slave network having a transmission speed of 1.25 MBPS; the maximum number of connected stations is 62. The transmission medium is an optical cable or a twisted pair line.

*6 Local Controller: A controller that is built into equipment, equipped with a CPU, and designed to have control features. A local controller is connected to an upper level controller using CC-Link.