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CONTROL SYSTEM FOR HIMAC SYNCHROTRON

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Abstract

A control system for HIMAC synchrotron has been designed. The system consists of a main computer, console workstations, a few small computers and VME-computers connected via Ethernet. The small computers are dedicated to the control of an injection line, an extraction line and an RF system. Power supplies in main rings are controlled by the VME-computers through FDI/FDO, DI/DO modules. This paper describes an overview of the synchrotron control system.

Introduction

HIMAC is a heavy-ion accelerator complex for the clinical treatment of tumors and now under construction at National Institute of Radiological Sciences. It consists of an injector, a synchrotron, a high-energy beam transport and an irradiation sub-systems. Heavy-ions with a charge-to-mass ratio as small as 1/7 are accelerated up to 6 MeV/u through an RFQ and Alvarez linacs and injected to the synchrotron sub-system.

The synchrotron sub-system has an injection line, an extraction line and a pair of separated function type synchrotron rings with almost the same structure. These rings operate independently at different energies and same ion-species except that power supplies of two rings are 180° out of phase each other. The output energy of each ring is designed to be variable in a range of 100 - 800 MeV/u for ions with $q/A = 1/2$. The general description about the HIMAC synchrotron was given in the previous article[1].

An overall control system for HIMAC consists of a supervisor computer and four sub-system control computers connected via Ethernet as shown in Fig.1. The supervisor computer is used for the global control of the whole system of HIMAC. It is also linked by hardware and/or software to the other equipments in this facility such as a water-cooling system, an air-conditioning system and a radiation safety system. The sub-system computers control individual devices and carry out programmed sequences for device groups. The control system for the injector was already reported[2]. The control system for the synchrotron is also designed in the same manner, that is, 1) each system is operated rather independently by reducing the data to be transferred each other, and 2) hardware and software concerned with a man-machine interface must be standardized among all sub-systems.

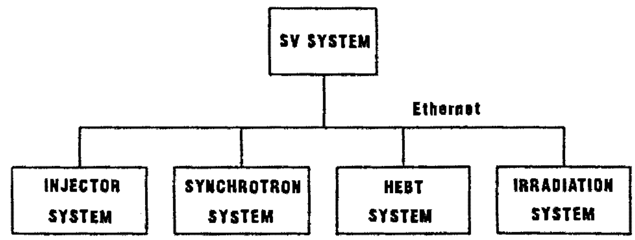

Fig. 1: A total control system for HIMAC consists of a supervisor computer and four sub-system control computers.

System Configuration

The synchrotron sub-system has many devices of different operational characteristics, for example, dc power supplies in the injection and the extraction lines, high-voltage power supplies in the RF system and the power supplies in the main rings operated with patterns or pulses. In order to handle these devices of different types efficiently and to reduce the load of the main computer, we adopted a distributed and hierarchical structure. A schematic view of the synchrotron control system is shown in Fig.2. Components and their functions are as follows.

A main computer and console computers

A main computer serves mainly as a man-machine interface and a file server. DEC VAX4000/300 is proposed for this purpose under VMS with 64 MB memory, 3 GB disk and communication interfaces for RS-232C, GP-IB and Ethernet. In the HIMAC system, parameters such as current values, current patterns, timing relations etc. are saved as a parameter file in the main computer and referred as the reference data in the next operation of the identical condition. The main computer has to manage this database and carry out programmed start-up and shut-down sequences using these files.

For a man-machine interface two operator consoles are available corresponding to two rings. Two VAX Station

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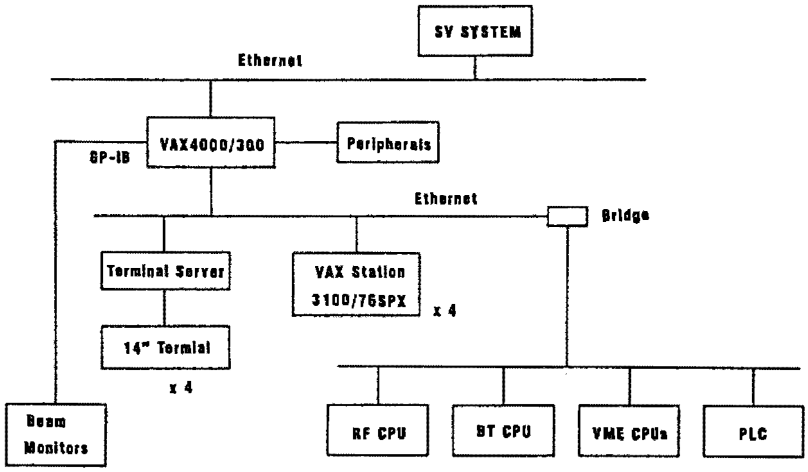

Fig. 2: A control system for HIMAC synchrotron.

3100/76SPXs with 16 MB memory and 104 MB disk and two 14-inch terminals are installed at each console for operation and display. Touch panels and rotary encoders are also equipped at the consoles and almost operations are performed by them with common procedures to the other sub-systems.

RF computer

A dedicated small computer connected via Ethernet controls the RF system including position monitors. Details of the RF control system are described elsewhere[3].

BT computer

The injection line from the injector sub-system and the extraction line to the high-energy beam transport subsystem are also controlled by small computers. Devices in both lines are mainly dc magnet power supplies, beam monitors and vacuum pumps except for a pulse magnet power supply to switch the injection beam to the upper and the lower rings. Device status, parameters and measured data are transferred through Ethernet.

PLC

A Programmable Logic Controller(PLC) is used as a interface between VAX4000/300 and the power supplies in the main rings to communicate ON/OFF commands, status signals and warning signals, although device parameters and measured data are transferred through DI/DO, FDI/FDO modules and VME-computers.

Power supply controller

All power supplies in the main rings are controlled by power supply controllers which consist of micro-computers and Digital I/O, Fast Digital I/O modules based on the VME standard. We plan to use 68000 family CPUs and a real-time, multi-tasking operating system, PDOS.

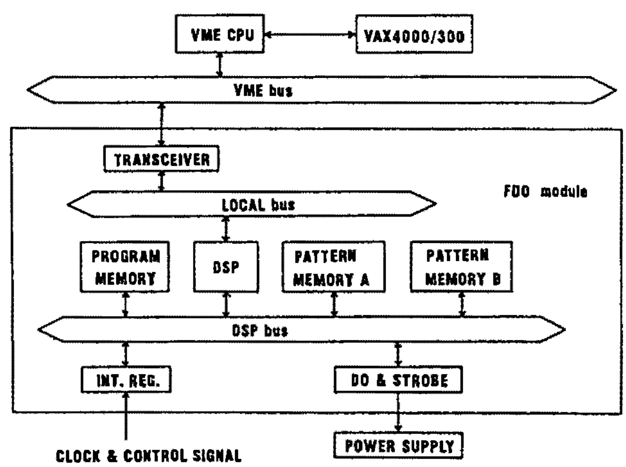

Fig. 3: A blockdiagram of the FDO module. The FDI module has almost the same structure.

The VME-computers communicate with VAX4000/300 via Ethernet and control dc power supplies through the DI and the DO modules.

On the other hand, the FDI and the FDO modules have been developed to control power supplies which should be operated with a pattern, such as a bending, a quadrupole and a bump magnet power supplies. A blockdiagram of the FDO module is shown in Fig.3. The FDO module has a Digital Signal Processor(DSP) and two pattern memories(A,B). The DSP sends data from the selected pattern memory to a power supply synchronizing with an external clock of 1200 Hz. While the DSP is reading and sending the data on the selected memory, new data can be written on the other memory, and then the memory is switched quickly from one to the other. The FDI module has almost the same structure and functions. This func-

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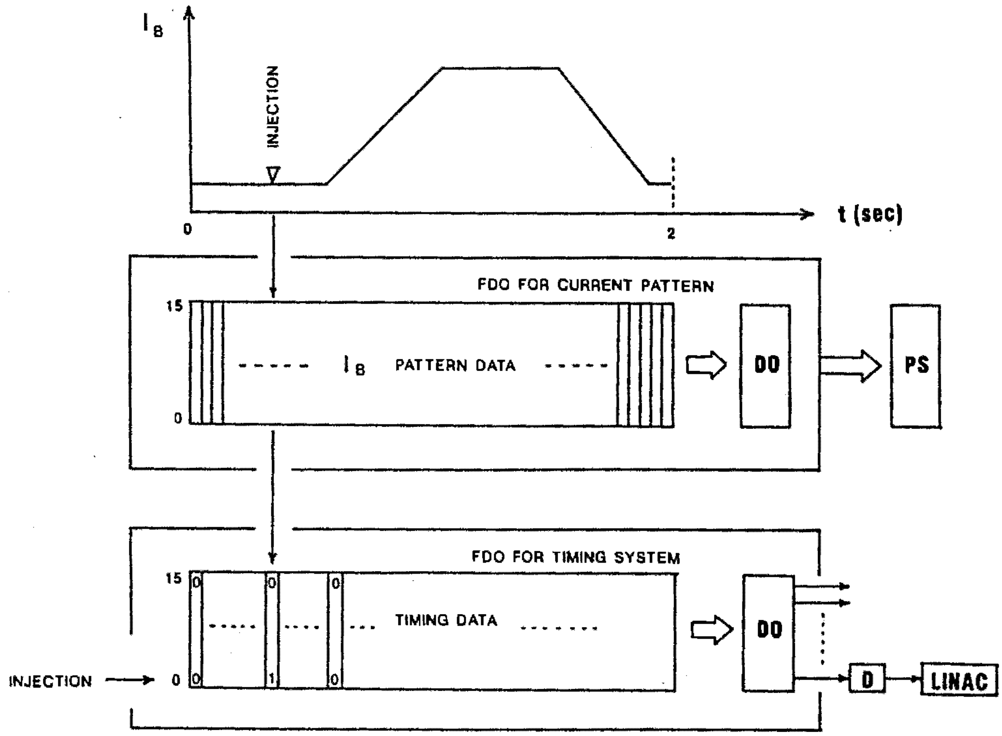

Fig. 4: A schematic view of the timing system. The FDO module is also used here.

tion plays an important role for a repetitive feed-forward pattern control of the bending and the quadrupole magnet power supplies in the main rings. In the feed-forward pattern control, the FDO module sends the reference data and the FDI module receives the measured data. Then the VME-computer calculates the correction pattern from the difference between the reference and the measured data using a transfer function of the magnet system and writes the new pattern on the background memory while the foreground memory is facing the power supply.

Timing System

A timing system is very important to synchronize the sub-systems because each sub-system is designed to be operated rather independently except for a software interlock among the sub-systems. Event signals are generated in the synchrotron sub-system and delivered to the own and the other sub-systems by hardware. As the bending magnet power supply consists of 24-pulse thyristor rectifiers and must be operated in synchronization with the ac power line of 50 Hz, the timing system generates clock signals of 1200 Hz (50 Hz × 24 pulses) phase-locked to the ac line voltage. The FDO module is also used for the setting of the event signals. A schematic view of the timing system is shown in Fig.4, where the synchrotron is operated, for example, with the repetition rate of 0.5 Hz. The FDO module for the current pattern data of the bending magnet has 2400 data of 16 bits and they are transferred in synchronization with the clock of 1200 Hz. The FDO module for the timing system has the data of the same size. In this case, however, not the 16 bit data but the rows of 0th - 15th bit have meaning because each bit is assigned to a specific event, for example, 'BEAM INJECTION', 'RF ON', 'ACCELERATION START', etc. The event signal corresponding to each bit is generated at the time when the bit is 'ON' or '1' and delivered through a delay controller.

Acknowledgement

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