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DESIGN OF CONTROL SYSTEM FOR RCNP RING CYCLOTRON

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ABSTRACT

A computer control system for RCNP Ring Cyclotron has been designed. The control system consists of a computer network and device controllers as the interface between accelerator devices and computers.

INTRODUCTION

The RCNP ring cyclotron which can accelerate protons and light ions up to 400 MeV and 100 MeV/amu has started to construct this year.[1] The ring cyclotron will use RCNP AVF cyclotron in operation as an injector. It is advantage to control both cyclotrons from the same operator console. However, the present operator console of the AVF cyclotron has been designed to control only AVF cyclotron and related beam transport lines. The control system of the AVF cyclotron is a digital control system using logic elements, and after operational experience of a few years it has been interfaced to a computer system.[2] Because the computing power of this control computer is limited, it is not desirable to control both cyclotrons by this computer. To construct new control system more efficiently, it has been decided that the control system of the AVF cyclotron is not modified or updated and it will be used manually. For the ring cyclotron new computer control system is adopted, and the computer system of the AVF cyclotron will be used for data logging at the first stage of the operation of the cyclotron cascade.

The operator console of the ring cyclotron will be installed near the present operator console of the AVF cyclotron, and it is designed to operate both cyclotrons by single operator. It is not planned to operate both cyclotrons from the same operator console in the early stage of the operation of the cyclotron cascade.

COMPUTER SYSTEM

The computers to control the ring cyclotron and beam transport system consist of a central computer (system control computer) and four sub-computers (group control computers). The control functions of the accelerator are distributed to five computers and many intelligent device controllers. Each group control computer is connected to the system control computer through a computer network Ethernet. Each group control computer is also connected to many device controllers of accelerator devices through an optical fiber serial lines.

The system control computer is a 32-bit mini-computer and controls the total system including group control computers and man-machine interface of operator console. The system control computer is in charge of a global control of the total system through the group control computers. The system control computer controls to start up and to shut down the operations of the accelerator devices, to maintain operation parameters, and to execute a man-machine interface through an operator console. The group control computers also consist of 32-bit mini-computers, and are used for the controls of cyclotron magnets, RF system, beam diagnostic devices and beam transport system including vacuum system and cooling system, respectively. The group control computers are in charge of a general control of groups such as a magnet system including beam injection and extraction devices, an RF system, beam diagnostic systems, and beam transport system. The control functions of group control computers are divided into two classes that are common to all group control computers and peculiar to individual computers. The functions common to all group control computers are the sequence controls of device groups under instructions from the system control computer, command analyses and executions that are sent from the system control computer, the control of device controllers by sending parameter values to set up, a man-machine interface between a local console of the computer and communications between other computers linked by the local area network. The functions peculiar to individual computers are the controls and the data handling of the accelerator devices contained in that gorup. The group control computer systems have no magnetic disk, and programs and device data are downline-loaded from the system control computer through the computer network at the staring time of the whole control system.

INTERFACE

To control power supplies and motor drived devices of the cyclotron, a device controller is used in each accelerator device. These device controllers are linked to sub-computers through optical fiber cables.

For the easiness of maintenance of the control components interfaces to accelerator devices are standardized. For these purposes a universal device controller (UDC) developed by Sumitomo Heavy Industries are adopted. The UDC contains an eight-bit microcomputer chip, IC memories (16 Kbyte ROM and 8 Kbite RAM) and related interface chips, and it is intended to reduce the computing load of group control computers.

The UDC's are installed in the cabinets of power supplies and the cabinets of the control modules of driving motors. To avoid the radiation damage of UDC modules, it is planned to install UDC's far from the cyclotron vault.

The basic functions of the UDC are as follows. The functions common to all UDC's are the communications to the group control computers and the status displays at the local panels connected to each UDC. In the power supplies of magnets, high voltage electrodes and RF system, UDC's are used for the periodic data accumulations, sequence controls among the power supplies, interlock checks among the power supplies, switching of polarities and loads of power supplies, slow speed controls of currents and voltages using a preset time constant based on a preset values of currents and voltages, and their stability checks. In the motor drived devices, UDC's are used for the periodic data accumulations, stability checks, the comparisons between the preset values and detected actual values and switchings of driving speed. In the beam diagnostic devices, UDC's are used for the control of the interlock sequence, and data acquisitions of beam currents. In the RF system, the vacuum system and the cooling system UDC's are used for the periodic data acquisitions, the sequence control, and the interlock checks among the device groups. The software of the UDC consists of the monitor program common to all UDC's and an application programs peculiar to each device.

For the interfaces to the devices, 32-bit digital inputs and 32-bit digital outputs are prepared. Moreover 16-bit bidirectional process input-outputs can be used as inputs or outputs. The UDC has an Intel iSBX bus, and it is possible to connect iSBX module boards such as ADC, DAC and GPIB. The UDC can also connect a local panel for the independent operation of each device, the maintenance of a device and a UDC, switches used in the local adjustments, and the status displays.

OPERATOR CONSOLE

The operator console consists of two console units and one analog signal display unit. Two console units are entirely identical, and two operators can adjust accelerator devices independently.

Each console unit has one 20-inch CRT display device with a touch screen and two 14-inch CRT display with touch panels. The present status of many control components is displayed on the 20-inch color display device. One of 14-inch CRT display device is used for a device selection, and the other is used for the adjustment of device parameters. However the assignments of the control functions to these displays are not fixed, and their usage should be flexible depending on various circumstances. For the parameter adjustments of accelerator devices four rotary encoders and two tracking balls are used. There are also eight general purpose color TV monitors.

The rotary encoders, the tracking balls, the touch screens, the 14-inch color CRT display devices are connected to the system control computer through RS232C serial interfaces. Large 20-inch color CRT display devices are connected to the system control computer through parallel interfaces, and enable rapid representations of graphic drawings and image processings.

The TV monitors display various images from many TV cameras located in the cyclotron vault, the beam transport lines and the experimental areas. The TV cameras are used to watch the present conditions inside the rooms where the radiation is in high level and the rooms of power supplies and cooling systems. The TV cameras are also used together with a beam diagnostic device and to observe the beam profiles in the ring cyclotrons and the beam lines. It is expected that an oscilloscope is used temporarily to observe signals from accelerator devices located far from the central control room. An easy method to observe this signal at the operator console is to use a TV camera. The softwares of the system control computer and the group control computers will become complicated. After the completion of the practical version of the control software, an easy-going way to add a new function to the control software is to use an additional personal computer. The TV monitors may be used for a display device of the personal computer and the control computer of the AVF cyclotron.

Although the status informations and analog signals from the control components are acquired by using the computer system, it is still necessary to handle analog data at the operator console. For these purposes four beam amperemeters and five digital oscilloscopes can be used. They are effective to observe the rapid changes of signals without additional time delay originated from the computers. The digital oscilloscope is also used as an input device through its GPIB interface to the system control computer. The operator can observe RF ripple signals from RF system and also beam profile signals from beam profile monitors located inside the ring cyclotron and the beam lines. A high speed digital oscilloscope is used to observe the high frequency signals from the beam phase monitors located in the cyclotron and beam injection and extraction systems.

STATUS DISPLAY SYSTEM

The operator console of the ring cyclotron will be installed in the control room of present AVF cyclotron. In front of the operator console of the AVF cyclotron, there exist status display panels of the AVF cyclotron, the beam transport lines, vacuum systems and cooling systems. These panels are very useful to monitor the accelerator status at a glance for not only the cyclotron operator on duty but also cyclotron crews off duty and even for visitors to the control room. Therefore these status display units are also necessary in new control system of the ring cyclotron. New operator console can display the accelerator status, but the number of the display units on the operator console is limited. If an operator wants to monitor the status of accelerator, beam line, vacuum system and cooling system simultaneously, the operator must select each item one after the other. To avoid these cumbersome operations, it is preferable to prepare some kinds of display panels near the operator console. For this purpose six sets of 16-bit personal computers with color display units are used. These personal computers are linked to the system control computer through the Ethernet, and display the global status of the ring cyclotron, beam transport lines, vacuum systems and cooling systems. The detailed software designs of the puersonal computers are in progress.

OPERATION MODES

The ring cyclotron can be operated with following three modes.

1) Operation at the local panels of power supplies and motor drived devices
   This mode may be used in course of construction and maintenance of the ring cyclotron. Each power supply and motor drived device can be operated independently, if an interlock requirement is satisfied.
2) Operation at the computer console terminal of the group control computer
   In normal operation of the control system the terminal of the group control computer is not necessary. By using this mode, it is possible to operate particular subsystem independently. It is expected necessary in the course of construction and a shut down of the system control computer. To provide against the trouble of the system control computer, one group control computer has a magnetic disk as a preparatory system disk. However the special software in the case of troubles with the system control computer is not designed until now.
3) Operation at the central operator console
   In the control system of the ring cyclotron this mode is popular and standard. The operations from the operator console consist of following four modes.

3A) Individual operation of power supplies and motor drived devices
3B) Operation in unit of a block
3C) Operation in unit of a group
3D) Operation of the whole system as one unit

The accelerator devices are classified into groups depending on their control functions. Examples of the "groups" are the main magnet and RF system. The accelerator devices of each group are divided into blocks depending on their control sequences. An example of the "blocks" is a general name of power supplies or driving motors contained in single acceleration cavity.

SOFTWARES

The control softwares of the ring cyclotron are in the stage of basic design. The control sequences of the start-up procedure, the adjustment procedure, the shut-down procedure and the recovery procedure from troubles have been analyzed partially until now. The partial charge of control softwares of system control computer and group control computers is now started to investigate. The control programs stored in the group control computers will be written by using a sequence interpreter developed for the control of accelerator by the Sumitomo Heavy Industries.

REFERECNCES

1) I. Miura et al., Proposal for Cyclotron Cascade Project, Proc. 11th Int. Conf. on Cyclotrons, Tokyo (1986) 207.
2) K. Hosono and T. Yamazaki, Computer Control for the RCNP AVF Cyclotron, Proc. 2nd Symp. on Accelerator Science, Tokyo (1978) 175.