

## OPERATION SOFTWARES OF RCNP RING CYCLOTRON

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### Abstract

A software for a distributed computer control system of the RCNP ring cyclotron is being developed. Operation screens, adjustment screens and display screens on the operator console have been designed. Both the hardware and software of the control system will be completed in 1990.

### Introduction

For the RCNP ring cyclotron a hierarchical computer control system is adopted.<sup>1)</sup> The first layer performs man-machine interface. The second layer controls subsystems such as magnets, RF systems and beam transport lines. The third layer controls each equipment. Each equipment is handled by each logical name. By introducing an interpreter language for the controls to describe an operation sequence of each device, it makes easy constructions and modifications of the softwares. The basic design of the control system was done in 1987.<sup>2)</sup> The control system is now in the step of construction.

### System Configuration

The control system of the ring cyclotron and beam transport lines consists of three layer control units. The first layer is a central computer microVAX 3500 named System Control Unit (SCU). The second layer consists of four sub-computers microVAX II or RT VAX named Group Control Units (GCU). The third layer consists of many controllers named Universal Device Controllers (UDC), which are used for the controls of power supplies and driving motors.

The control functions of the ring cyclotron and the beam transport lines 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 by an optical communication system.

### System Control Unit

The system control computer has charge of a concentrated control of the total system and a man-machine interface. The system control computer controls to start-up and to shut-down the operations of the devices, to maintain operation parameters, and to execute a man-machine interface through an operator console. The system control computer also manages operation parameters as a database to make easy parameter settings and adjustments.

### Group Control Units

The group control computers are used for the controls of cyclotron magnets and injection beam line, RF systems including vacuum and cooling systems, beam diagnostic devices and beam transport lines, respectively. The group control computers have charge of a general control of group such as a magnet system including beam injection and extraction devices, RF systems, beam diagnostic devices and beam transport lines. 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 group under instruction 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 setup, a man-machine interface between a local console of the computers 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 devices contained in that group. 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 starting time of the whole control system.

### Operator Console

The operator console consists of two console units. Two console units are entirely identical, and two operators can adjust devices independently.

Each console unit has one 20-inch CRT display device with a touch screen and two 14-inch CRT displays with touch screens. One of 14-inch CRT display is assigned to operation screens, which are used for a device selection, start and stop, and other operations except parameter adjustments using rotary encoders. The other of 14-inch CRT display is assigned to adjustment screens, which are used for the parameter adjustments. The 20-inch CRT display is assigned to display screens, which are used to display data numerically and graphically.

### Touch Screen Operation

The man-machine interface of the present system is based on the operations on touch screens. The picture layouts especially layouts of the touch screens are realized not by the procedure in each program but by the independent picture attribute tables and files. Interpretation and display of input informations are executed by referring these tables. By modifying attribute tables during the execution time, the modifications of the display contents are possible. Screen layouts can be prepared by editing screen attribute files by using related utility programs.

The response speed of the key operation is important for its operation performance. In the present system it is expected to change the screens frequently, a screen handling system for this system is prepared. To minimize the amount of transmitted data for an update of the screen, the screen is not refreshed periodically, but the necessary data are transmitted to the screen at necessary time.

### Touch Screen Software

The touch screens are one of the input devices on the operator console. An input management task of the touch screens is common to each screen. However actual display to each CRT display is different for each screen and has a strong independence especially on the display screen. Therefore single common display task is not considered here, and each screen has its own display task. The status of each task is changed to the start/stop/wait status by a touch screen management task receiving the information of key inputs. The periodic modification of the display contents is performed as the process in each task, and if necessary child tasks may be generated.

### User Defined Screen Layout

In the present system it is necessary to consider the addition of the user tasks after the completion of the system. It is necessary to modify the contents of the operation screens easily from user programs and to modify the data on display screens.

Screen layouts are described by the screen attribute files which are independent from user tasks. Basic procedures relating to the screen exchange and the modifications of attribute and display contents are prepared as runtime libraries. Individual area of the display panel is open to application programs. Each task can draw on the display screen directly by using graphic libraries.

### Hierarchy of Tasks

For the easiness of a system modification and a program addition after the completion of the system, in the present system tasks are classified to two levels of basic tasks and application tasks.

The basic tasks are constituted by screen management task, touch screen management and communication management task group. They are basic task groups to execute basic functions of the system. A modification of basic tasks between the individual systems is expected to be little.

The application tasks such as individual screen display tasks and control tasks are updated very often for individual system. User programs added after the system completion are included in the application tasks. Application tasks realize application dependent functions by using the functions of the basic tasks. These functions are accumulated in libraries of the basic tasks.

### Standard Library and User Interface

The many functions realized as the man-machine interface are used commonly in many screens. Therefore, by classifying these functions and preparing them as library, a standardization of the systems

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### Adjustment Screen

The adjustment screen, shown in Fig. 3, is a screen used only for the parameter adjustments by using rotary encoders, tracking balls or ten keys. The devices to be adjusted are selected by device selection screens in the operation screen, and one can select up to four devices simultaneously. Each device has six parameter items; reference value, preset value, actual value, +delta R value, -delta R value and delta P value. The reference value is loaded from a parameter file, and this value is set to a preset value at the loading time. It is impossible to adjust this reference value. However, on saving them to a parameter file, the preset value is saved as this reference value. The preset value is used to control current or voltage of a power supply and position of a motor-driving device. The Universal Device Controller generates a driving pattern for each device from the present actual value to this preset value if necessary. The actual value is a measured value of the device parameter. For the power supplies actual current values measured by using shunt resistances are displayed as the actual values. For the driving systems by using stepping motors the position values evaluated from the output pulses of the UDC correspond to the actual values. The +delta R and -delta R values show an adjustment range. If one set the preset value outside this adjustment range by using the adjustment screen, its preset value is restricted to reference+(+delta R) or reference-(delta R) value. The delta P value indicates a stability range. When the actual value exceeds the range determined by preset+(+delta P) and preset-(delta P) values, the UDC can set stability error bit. If one registers this bit to an interlock check table in a group control computer, it is possible to detect it as a fault status of the device. If one registers this bit to an alarm trend table, it is possible to measure the parameter trend of the device in bad stability status automatically.

### Display Screen

The display screen is divided into three areas, a common display area, an individual display area and a menu area.

Three uppermost lines of the display screen are assigned to the common display area. The undermost line is used for an operation message area such as an alarm message against a mistake of cell input. The individual display area covers from the fourth line to the 47th line, and is used by each screen display program. The menu area is also included in the area from the fourth line to the 47th line, and the necessary cells for each screen display program are prepared.

In the display screens the following operation informations are displayed.

#### 1. Main Menu

The main menu is the primary menu screen that is displayed at the starting of the computer system, and is mainly constituted by a menu selection of the subsequent operation screens.

#### 2. Device Status

The devices are classified to groups. If one selects a group at the main menu, the device status belonging to its group is displayed. The device status of the power supplies is not ready, ready, operation or fault state. The device status is updated at an interval of 100ms.

#### 3. Not Ready Device List

If one selects this screen, the detailed informations of the devices in the not ready states are displayed.

#### 4. Fault Device List

If one selects this screen, the detailed informations of the devices in the fault states are displayed. The fault device lists are registered

Common Information Display Area									
Common Information Display Area									
DYNAMIC PARAMETER RING									
GROUP	DEVICE	REF/PRESET	ACTUAL	FIELD	BLOCK	DEVICE	REF/PRESET	ACTUAL	FIELD
TRIM2	TRIM 03	300.000A	300.000A		MAINC	MAINC01L	300.000A	300.000A	
	TRIM 04	300.000A	300.000A			AUXC 1	100.000A	100.000A	
	TRIM 05	300.000A	300.000A			AUXC 2	100.000A	100.000A	
	TRIM 06	300.000A	300.000A			AUXC 3	100.000A	100.000A	
	TRIM 07	300.000A	300.000A			AUXC 4	100.000A	100.000A	
	TRIM 08	300.000A	300.000A			AUXC 5	100.000A	100.000A	
	TRIM 09	300.000A	300.000A			AUXC 6	100.000A	100.000A	
	TRIM 10	300.000A	300.000A						
	TRIM 11	300.000A	300.000A						
	TRIM 12	300.000A	300.000A						
TRIM2	TRIM 13	300.000A	300.000A		TRIM2	TRIM 01	300.000A	300.000A	
	TRIM 14	300.000A	300.000A			TRIMC 1	300.000A	300.000A	
	TRIM 15	300.000A	300.000A			TRIMC 2	300.000A	300.000A	
	TRIM 16	300.000A	300.000A			TRIMC 3	300.000A	300.000A	
	TRIM 17	300.000A	300.000A			TRIMC 4	300.000A	300.000A	
	TRIM 18	300.000A	300.000A			TRIMC 5	300.000A	300.000A	
	TRIM 19	300.000A	300.000A			TRIMC 6	300.000A	300.000A	
	TRIM 20	300.000A	300.000A			TRIMC 7	300.000A	300.000A	
	TRIM 21	300.000A	300.000A			TRIMC 8	300.000A	300.000A	
	TRIM 22	300.000A	300.000A			TRIMC 9	300.000A	300.000A	
TRIM2	TRIM 23	300.000A	300.000A		SSC	SECTOR1		10000.000	
	TRIM 24	300.000A	300.000A			SECTOR2		10000.000	
	TRIM 25	300.000A	300.000A			SECTOR3		10000.000	
	TRIM 26	300.000A	300.000A			SECTOR4		10000.000	
	TRIM 27	300.000A	300.000A			SECTOR5		10000.000	
	TRIM 28	300.000A	300.000A			SECTOR6		10000.000	
	TRIM 29	300.000A	300.000A						
	TRIM 30	300.000A	300.000A						
	TRIM 31	300.000A	300.000A						
	TRIM 32	300.000A	300.000A						
TRIM2	TRIM 33	300.000A	300.000A						
	TRIM 34	300.000A	300.000A						

Ref	Preset	Actual	Other

Next Phase	Prev. Phase	Disp	Next	Prev.

Ref	Preset	Actual	Other

Operation Alarm Display Area

Fig. 4 Dynamic parameter screen.

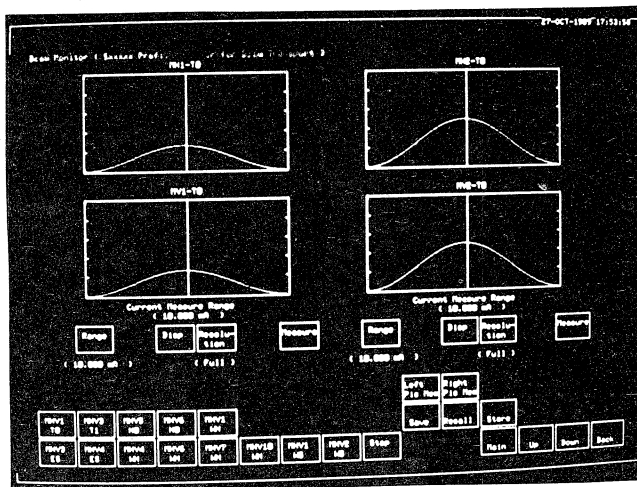


Fig. 5 Profile monitor screen.

with phase numbers. The phase 0 indicates the time immediately (100ms) before the fault detection. The phase 1 indicates the occurrence time of the first fault. After the phase 2 new phase number is registered whenever new fault occurs. The fault device lists are cleared by pushing FT(fault) reset cell on the adjustment screen.

#### 5. Dynamic Parameter (Fig. 4)

The device parameters expressed numerically are, for example, currents and voltages of the power supplies, positions of motor driven devices, temperatures of devices, and pressures in the vacuum systems. They can be displayed in the display screen dynamically. Therefore these device parameters are called the dynamical parameters. If one selects this screen, reference values, actual values, +delta R values, -delta R values, and delta P values for the devices are displayed.

#### 6. Trend Display

The variations of the actual values for the devices selected previously by using operation screen are displayed graphically.

#### 7. Maintenance Plan

Total operation time for each device is displayed, and gives a guidance for the maintenance period.

#### 8. UDC Status

The status of the Universal Device Controller is classified to disconnected mode, local mode or remote mode. The present status of UDC is displayed.

#### 10. Graphic Display

The graphic display screens show the positions and status of devices such as magnets, beam diagnostic devices and vacuum pumping stations of the ring cyclotron and beam transport lines.

#### 9. Beam Diagnostics (Fig. 5)

For the displays of beam diagnostic devices several special display screens are also prepared.

### Utilities and Other Programs

In addition to the programs described above, the following utility programs are being developed. They are system start and system stop utilities, logging file utility, parameter file saving utility, data handling utilities for the beam diagnostic devices, index editor of parameter file, communication facility to addin computers, and alarm trend facility.

### Conclusion

The control functions are distributed to the group control computers and the Universal Device Controllers, and simultaneous adjustment and operation become possible. The softwares relating to the operations at the operator console are designed to realize the standardization of operations, and the easiness of screen selections and adjustment operations. The easiness and flexibility for the modification of preset data and programs are also considered.

### References

- 1) T.Yamazaki, et al., Design of Distributed Control System for the RCNP Ring Cyclotron, Proc. Twelfth Intl. Conf. on Cyclotrons and Their Applications, Berlin(West) Germany, 1989.
- 2) T.Yamazaki, et al., Design of Control System for RCNP Ring Cyclotron, Proc. Sixth Symp. on Accelerator Science and Technology, Tokyo, 1987, pp.251-252.