OPERATION SOFTWARES OF RCNP RING CYCLOTRON

T. Yamazaki, A. Ando, K. Hosono, T. Itahashi, I. Katayama, M. Kibayashi, S. Kinjo, M. Kondo, I. Miura, K. Nagayama, T. Noro, T. Saito, A. Shimizu, M. Uraki and H. Ogata

Research Center for Nuclear Physics, Osaka University Mihogaoka, Ibaraki, Osaka 567, Japan

and

K. Aoki and K. Kodaira*

Accelerator Business Center, Technological Department, Sumitomo Heavy Industries, Ltd. Yato, Tanashi, Tokyo 188, Japan

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.¹⁾ 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 1987.²⁾ 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 manmachine 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 cy-clotron magnets and injection beam line, RF systems including vac-uum 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.

* Systems Development Department

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 consid-ered 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.

<u>Hierarchy of Tasks</u>

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 func-tions 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 and the simplification on the development of user tasks are attempted.

The library includes the screen management, the manipuration of screen management data, the touch screen driver module, the encoder driver module, the tracking ball driver module, the inter-task communication driver module, miscellaneous data handling driver modules, the screen display modules including cell displays, data displays, macro function modules of ten keys and alpha-numeric keys, and graphics modules.

The man-machine interface part of the present system must be flexible for the modifications and additions by users. Here, the users are classified to following two levels; the operator level and the user programmer level. The operators can modify the screen layout by using utility programs. The user programmers can add new screens to the system. The additions of new screens are performed by the following steps.

- 1. Design and registration of the screen layouts. For the necessary cells in the screen the corresponding data are assigned.
- 2. Addition of keys to select user screens. In the operation screens and display screens the keys are added to vacant cell areas, but in the adjustment screens the addition is not allowed.
- 3. Creation of the display tasks. By using the standard library, it is easy to programming the tasks on intelligent display screens.
- 4. Starting of the display task. These tasks are started from the operator console. By pushing the corresponding cell, the created screen is displayed.

Operation Screen

By pushing touch area on the touch screen of the operation screen, an operator can perform many operations such as executions of start/stop sequences and on/off operations of devices except the adjustments using rotary encoders.

The operation screens are managed by a screen directory in hierarchy structure. In common touch area some touch cells for the change of touch screens are provided. They are a cell to return to main menu, a cell to return to the screen of one rank higher hierarchy, a cell to go upstream to the previously selected screen according to its history, and a cell to go downstream reversely to a screen according to the history. Moreover, besides above touch areas special touch areas are also prepared to the screens having higher possibility at the next selection of the normal operations, and a simplification of operator manipuration is realized.

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. Parameter File Loading

The system control computer manages and saves parameter files for the parameter settings on the system operations. The parameter files can be loaded to the computers and the universal device controllers by inputing its filename.

3. Device Selection (Fig. 1)

In this screen one can select the devices to adjust the parameter values by using rotary encoders, tracking balls or ten keys.

4. Trend Parameter Selection

This screen is used for the settings of the trend periods and the selections of the trend items. Three screens for the trend displays



Fig. 1 Start/stop screen.

INJ	FOTUE	OTHE	DEVICE S	ELECT (OIZK:	0120	913U	0130
1110		1						
BIÉ	BIZ.	BIT	BI4	HICE	MICLC	nicz,	EICL	EICZ
SIVIL	STRIE	SIVIZ	QNE		EICE ENFLEOS	EICL Ext_pos	EICZ ENT_POS	EIC2 Ext_Pos
EXT	ONLUE Die	ONID L	OMZUR 28	onsk T	9H2DR 4		EECL ENFLPOS	EEC1 Externs
æ	EME	HECE	HECZ	FICE	EEC2.		DECZ ENF-PUS	EECZ Externs
					<u>-5 (</u>	CANCEL	NEXT	
PARAM	PARAK	PARAM	PARAM	Ī	HAIN	UP	DOHN	BACK

Fig. 2 Device selection screen.

are prepared, and each display shows eight parameters. The present system has the facility to acquire the device trends automatically from the devices in bad stabilities.

5. Start/Stop (Fig. 2)

The devices in the ring cyclotron and the beam transport system are classified to groups and blocks. Each group is constituted from blocks. This start/stop screen controls the start, stop and pause operations of devices in the group mode or the block mode. Here the pause operation means an interruption of the group and block managements.

6. Device Operation

This screen is used to detach a specific device from the group and the block to allow the start and stop operations of individual device. The screen has an attach function to link the device to group and block modes.

7. Report Printing

It is possible to print the logging data periodically or at will. 8. Meter Selection

On the operator console eight analog meters are installed for the quick measurements of beam currents on beam stoppers and slits. This screen is used for the meter selections.

9. TV Camera and Monitor Selection, and Beam Viewer Selection This screen selects a TV camera and assigns it to a TV monitor on the operator console. In case of a beam viewer selection, corresponding camera is also assigned simultaneously.

11. Other Screens

The following operation screens are also prepared; the gate valve operation, vacuum system operation, manipuration of the beam monitor offset, power supply load change in the beam transport line, beam course selection, beam stopper operation, and other operations.

Paran	RING 1	MAINC MAIN	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	(XXXXXX
	COIL	1	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXX
REF		300.0 (A)	XXX.	X (A)	-XXX.	X (A)	XXX	.X (A)
PRESET		280.0 (A)	XXX.		-XXX.	.X (A)	XXX	(A)
actual		281.2 (A)	XXX.	X (A)	-XXX.	.X (A)	XXX	.X (A)
+ dR		20.0 (A)	XX.)	((A)	XXX.	X (A)	XX.	X (A)
- dR		18.0 (A)	XX.2		XX.)		XX.	X (A)
dP		0.001 (A)	X.X	(X (A)	X.X)	(X) (A)	Χ.Χ	XX (A)
	Enc A	Slow	Enc B	Fast	Tball B-X	Slow	Ten Key	
	Prese	t dP		÷	-	7	8	9
	+ dR	- dR		Del		4	5	6
	Faul Rese			Enter	0	1	2	3

Fig. 3 Parameter adjustment screen.

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 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 measued by using shunt resistances are displayed as the actual values. For the driving systems by using stepping motors the posiotion 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 exceedes 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 an individual display area and a menu area. Three uppermost lines of the display screen are assigned to the area,

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



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 drived 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 pa-rameter 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.
- T. Yamazaki, et al., Design of Control System for RCNP Ring 2)Cyclotron, Proc. Sixth Symp. on Accelerator Science and Technology, Tokyo, 1987, pp.251-252.