CONTROL SYSTEM OF THE RIKEN RING CYCLOTRON

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Abstract

The RIKEN ring cyclotron system is controlled by means of three mini-computers, which are linked with one another through optical fiber loops. A CAMAC serial crate network and a GP-IB are used for the control of accelerator devices. Two types of intelligent modules are used; one is a CAMAC module and the other is a terminal module for high-speed local control of the accelerator devices. The operating system OS60/UMX is a combination of a real time and a UNIX system. Application programs are written in FORTRAN 77 language. Most operations are performed by touch pannels.

Introduction

The construction of the RIKEN ring cyclotron is almost completed.[1] The control system consists of three mini-computers; the first one is for data base and program development, the second one is for the control of injector linac(RILAC), and the third one is for control of ring cyclotron. These computers are linked with one another through optical fiber loops.

The parameter values are transferred between the accelerator devices and computers through a CAMAC serial network. Two types of intelligent modules are used for high-speed local control of the accelerator devices.[2] One is a CAMAC module and the other is a terminal module. A micro processor is integrated in each module.

Computer System

Figure 1 shows a block diagram of control system. Three mini-computers are linked by using glass optical fiber cables. The computers are of the same type, a 32-bit industrial computer MELCOM 350-60/500(M-60) of Mitsubishi Electric Corp.. The characteristics of this computer were already reported.[3] The network is a duplex system. Even in the failure of one line or failure/power-off of any one computer, the computer link can be retained automatically by adopting a loop back method. The transmission rate is 15.36 Mbps.

This computer system has other two types of computer networks; one is an Ethernet and the other is a UNIX network. Program and data transfer and local diagnostics are performed by using these networks.

Computer 1 stores the field mapping data of sector magnets and transport magnets. At a request from any control computer(computer 2 or 3), time consuming tasks such as orbit calculations and transport calculations are performed by computer 1 using these mapping data and the results are sent back to the control computer.

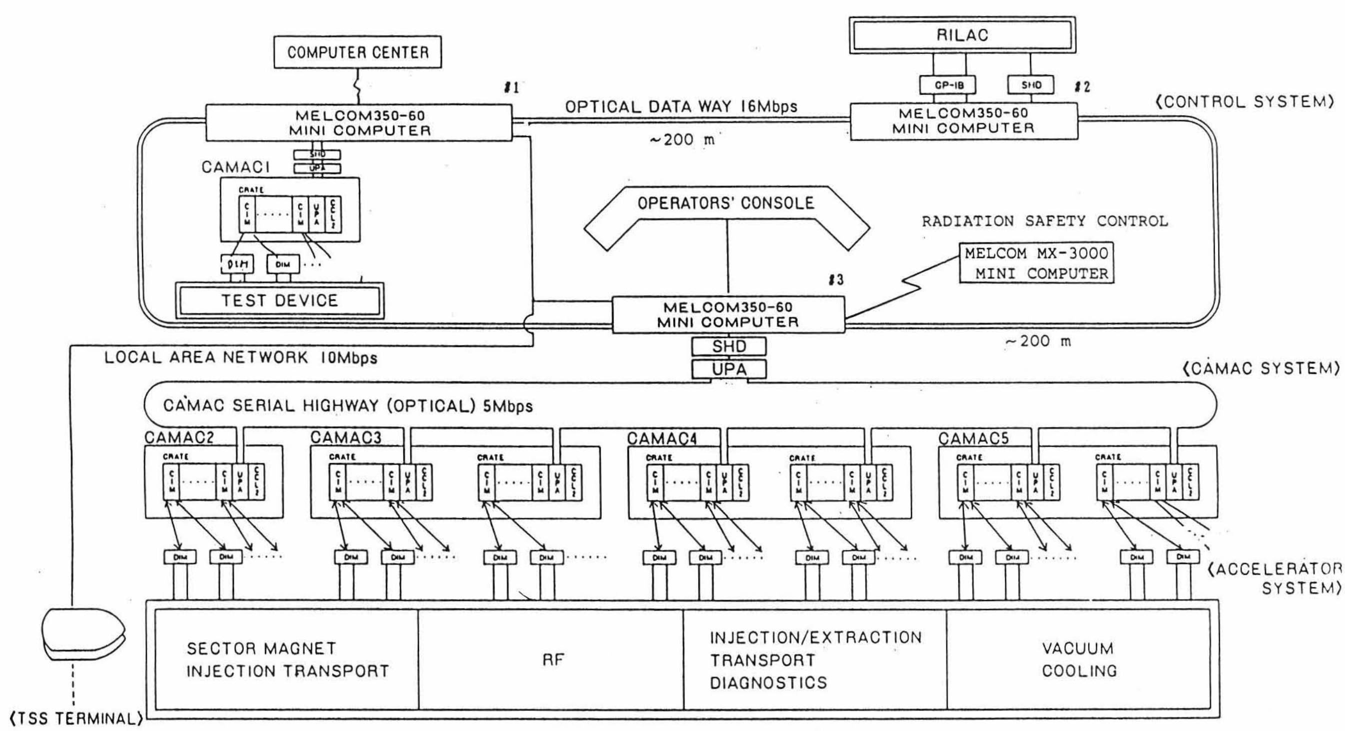

Fig. 1. Block diagram of Control system.

Computer 1 is equipped with a CAMAC SHD and can be used as a back-up computer for the control computers. Computer 1 is also linked to the central computer of our institute (FACOM M-780) in order to ask for jobs in which larger memory and higher computation speed are necessary.

Computer 2 controles the RILAC through GP-IB using optical fiber links.

Computer 3 controls the ring cyclotron through the CAMAC bit serial loop. The console devices such as touch panels and color displays are linked to computer 3 without a CAMAC system. This computer is also linked with the computer (MITSUBISHI MX-3000) of radiation safety control system. For radiation safety, MX-3000 has the highest priority. Before starting operation, an operator should ask MX-3000 for permission. If any erratic conditions occur in the safety system during operation, MX-3000 send back a beam-stop command.

Computers 1 and 3 are installed in the control room of ring cyclotron and computer 2 is in the control room of the RILAC.

Interface System

Six CAMAC crates are distributed in four power supply rooms. One is installed in an operators' console. Because of the long distance (90 m max.) between these rooms and the control computer, these CAMAC crates are linked by a bit serial CAMAC loop of optical fiber cables; the transmission rate is 5 Mbps. A disadvantage of this optical loop is that it has no bypass function when one crate is powered off.

Two types of module which integrate microprocessor are used for the interface between controlled devices and the CAMAC system. CIM is a CAMAC module and DIM is an interface module to each controlled device and installed closely to the device. CIM executes the message transfer between the M-60 computer and DIM. Informations are transferred between CIM and DIM through plastic optical fiber cables. The maximum length of this cable is limited to 30 m. DIM executes a local sequence control, local surveyllance, function generation, and testing, thus reducing the load of the control computer. Each DIM has several digital input/output (DI/DO) ports and sixteen analog input (AI) ports. The DI/DO ports of DIM for power supply are of a 12 V opto-coupled type. DIM for beam diagnostics has TTL level DI/DO ports in order to carry on such high-speed exchange of data as that from beam profile monitor or emittance measuring system. For the control of main differencial probes (MDP), DIM are linked with a dedicated microprocessor. Since high-speed control is performed for the RF system by programmable controllers (PC), the main jobs of DIM are start/stop and monitoring. Status and analog values are sent to control computer through CIM/DIM system. A vacuum control system also uses PC. Almost all interlocks and sequence control are performed by the PC. The vacuum gauges and temperatures of cryopumps are read by DIM. A residual gas analyzer (QMA) is controlled by a dedicated microcomputer and the data are sent directly to the control computer through optical RS232C lines. For a cooling system, DIM only reads the status.

The total numbers of CIM and DIM are 30 and 170, respectively.

Diagnostic Network

Diagnostics of controlled devices is carried out conveniently by verifying the response of the devices. For this local diagnostics, a local area network (Ethernet) with a transmission rate of 10 Mbps is used. Four interface terminals (TIA) are prepared; two are placed closely to computer 1 and 3, the other two are closely to the CAMAC stations. Diagnosis is carried out by plugging a TSS terminal unit into a port of a nearest TIA. These ports are also used for displaying machine status in an operator room or counting rooms by selecting a desired part of the machine on a keyboard. Since this network links two computers (computer 1 and 3), an operator is accessible to each computer.

The computer system is equiped with one more network; UNIX network. This network can be used only in UNIX OS and not in real time OS.

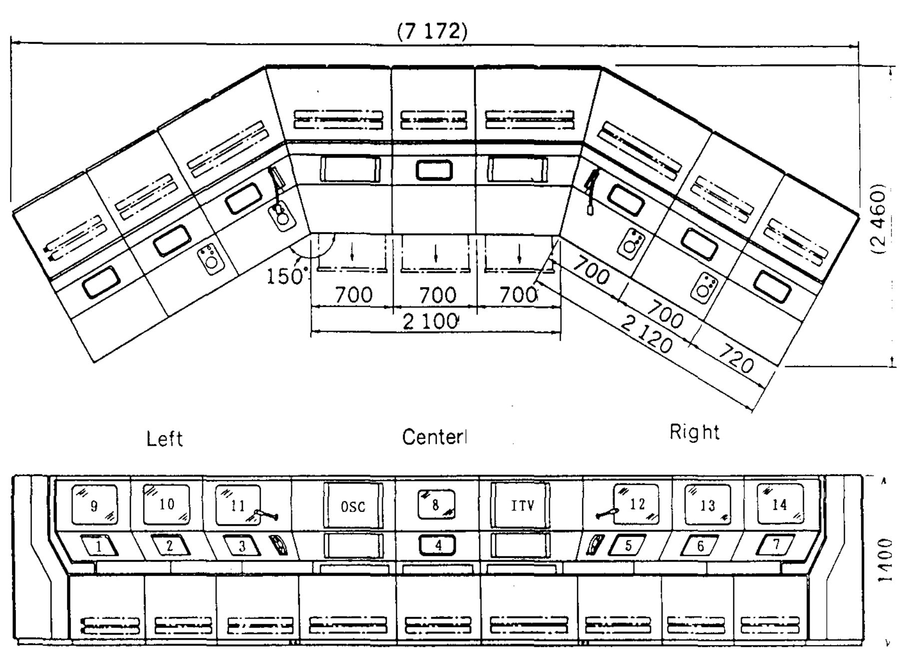

Fig. 2. Operators' console.

Console

Figure 2 shows the operators' console, which consists of three parts (center, left, and right parts); the left and right parts are made equivalent to each other for the convenience of diagnostics of accelerators. At least two operators can access the accelerator system independently. The console devices are linked directly to computer 3 without the CAMAC inteface. Because of an industrial computer, there are many convenient and powerful man-machine interface devices and softwares. The center part is prepared for the devices such as ITV's, scopes, and error message output CRT. CRT's, #1 - #7, are model VT241 of DEC with touch pannels(TP) on the screens. CRT #8 is VT241 without TP. CRT's, #9 and #14 are low-speed full graphic displays, #10 and #13 are high-speed full graphic CRT's, and #11 and #12 are character displays.
Allmost all man-machine interactions are performed by the TP's and the informations are diplayed on the CRT's, #9 - #13. The first assignment of the role to each TP is done at the center TP(#4). Figure 3 shows the center TP display. Figure 4 is an example of the TP display for the control of power supplies. In this case, maximum four power supplies are controlled on the same screen. The assignment to other parts is changed by pushing the upper right four buttons.

Software

The application programs are written in FORTRAN 77 language. The steps of these programs amount to several tens of thousands. The data base about accelerator devices are almost completed. They are first created in disk files and at initial program loading time are loaded into a common area of memory. The required memory is about 20 KB. In our computer, different tasks occupy independent logical memory space in order to avoid addressing overlaps. These tasks exchange information through the common area. This common area can be also accessed by other computer through a data way.

Many kind of programs which deal with man-machine interface with TP have been developed. We can use TP conveniently and flexibly, and lay out various types and colors of push buttons rayout on it The programs for DIM of power supply are extensively improved to get high-speed execution.

Since the programs of CIM/DIM are written in assembler language it is a little inconvenient for the maintenance. Then we are now going to use high level language.

Acknowledgments

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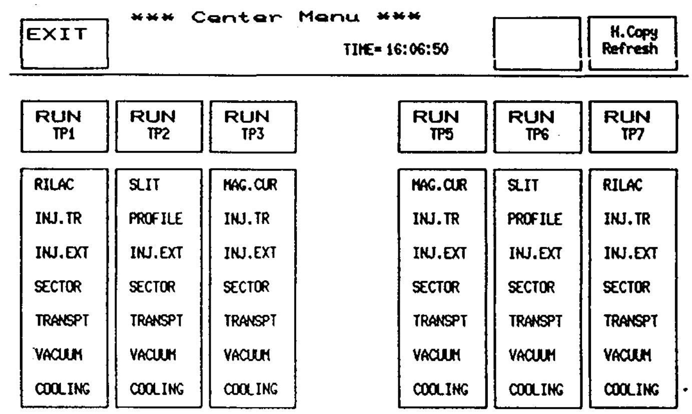

Fig. 3. The display on the center touch pannel.

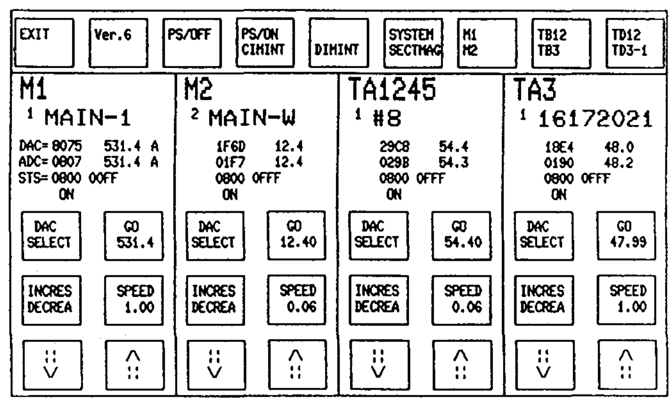

Fig. 4. An example of TP display for power supply control.