

Accelerator Control Systems in China

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Abstract

Three accelerator facilities were built in the past few years, the 2.8 GeV electron positron collider BEPC, the heavy ion SSC cyclotron accelerator HIRFL and the 800 MeV synchrotron radiation storage ring HESVRL. Aimed at different research areas, they represent a new generation of accelerator in China.

This report describes the design philosophy, the structure, performance as well as future improvements of the control systems of these facilities.

I. INTRODUCTION

The development and research of accelerators in China has made good progress in the past thirty years. Many low energy accelerators for research and application have been constructed, including high voltage type accelerator, cyclotron, linear accelerator, betatron etc. Their application covers a wide range: medical treatment, industrial irradiation, non-destructive inspection, isotope production and many other fields. The three newly completed high and medium energy accelerator facilities, Beijing electron positron collider (BEPC), Lanzhou heavy ion research facility (HIRFL) and Hefei synchrotron radiation source (HESVRL), aimed at different scientific research areas, represent a new generation of accelerator facilities.

Early accelerators are mostly controlled by panel meter and push button type manual control system. Application of microcomputers to accelerator control system started at the beginning of 80's when microcomputers were becoming popular in China.

This paper is not intended to be a general survey. Control systems of the three new accelerator facilities, which are relatively larger in scale and more complicate in structure, are described here with the emphasis on the system architecture.

II. BEPC CONTROL SYSTEM

BEPC is the first high energy accelerator built in China. The main facilities of BEPC are a 1.4 GeV electron linear accelerator injector, a 1.4 GeV beam transport line and a 2.8 GeV electron storage ring. The project was started in 1984 and completed in 1989.

Because of the strict time table for the

BEPC project, the leaders of the project decided early in 1985 that in order to reduce development work and shorten the construction period the new control system of SPEAR ring should be adopted as the base for BEPC.

BEPC control system is a typical centralized control system. A VAX11/750 serves as the central control computer. Serial CAMAC systems are the base for equipment interfacing.

1. System Configuration

Fig. 1 is a block diagram of BEPC control system. The system is functionally divided into three levels.

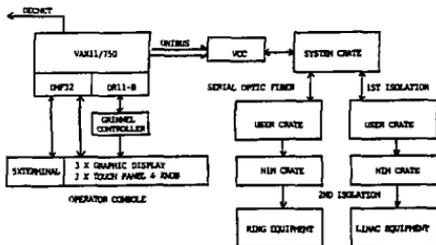


FIG. 1 BLOCK DIAGRAM OF BEPC CONTROL SYSTEM

First, at the center of the system is the DEC VAX11/750 computer, which is equipped with an asynchronous serial interface board for connecting terminals and knobs, a DR11-B DMA interface for connecting color display monitors, and other standard peripherals such as hard disks, printers, tape drivers etc. A SLAC designed Vax CAMAC Channel (VCC) is the key element in data communication network. It is a DMA controller to interface VAX11/750 UNIBUS with CAMAC system. Two CAMAC system crates are controlled by the VCC, one for the linear accelerator the other for the storage ring. One system crate houses several serial branch driver modules and each branch driver starts a fiber optic serial high way loop which connects up to 7 user CAMAC crates. The second level is the local control stations formed by user crates. I/O functions are performed by the local control stations. Each local control substation controls one

written in FORTRAN. They accept main console command, generate various displays and send control command and data to CAMAC crates or to the control substations.

Software for the substations were written with FORTRAN and BASIC languages. Menu type man-machine interfaces are implemented for convenience of operation. The substation control programs perform all the basic control functions: equipment parameter adjustment, on/off control, status monitoring and generation of local status displays.

3. Present Status

All the control substations were completed in 1988 and was in operation before the beginning of SSC commissioning. They have satisfied the requirement of HIRFL commissioning and operation.

A system composed of two 386 PCs and CAMAC systems were built for the SFC control recently.

The VAX cluster was installed in Jan. 1988. A VAX control program for SSC magnet power supply system is completed and in operation. Development of VAX central control programs for other subsystem is under way.

The next goal of HIRFL control group is to realize central control of all SSC and the SFC equipments.

IV. HESYRL CONTROL SYSTEM

HESYRL is a dedicated synchrotron radiation source designed for UV and X-ray experiments. The project started in 1984 and completed in 1989.

The main facilities of HESYRL are a 200 MeV electron linear accelerator, a beam transport line, and an 800 MeV electron storage ring. The control system are mainly divided into three relatively independent parts: a linac control system, a ring control system and a timing system.

1. System Configuration

The HESYRL ring control system is a distributed computer control system composed of a PDP11/45 computer, two 286 PCs, a communication microcomputer and up to 40 local control microcomputers(LCM). Fig. 4 is a block diagram of the ring control system.

Originally we plan to use a VAX11/780 as the main control computer. Both budget and delivery time problem led us to the choice of a PDP11/45 computer as a temporary alternative. Now because of the small memory size and poor display ability, its function is reduced to part of communication. Main control functions and console operation are all performed by the two PCs which are connected to serial ports of the PDP.

Ring equipments are controlled by local control microcomputers. Most of them are MULTIBUS system composed of a crate, a CPU board, a serial communication/memory

expansion board and a several other interface boards. Because PCs are more convenient in programming and display we have also used some PCs as LCMs. The LCMs are located near the equipments. One LCM controls only one or one type of equipments.

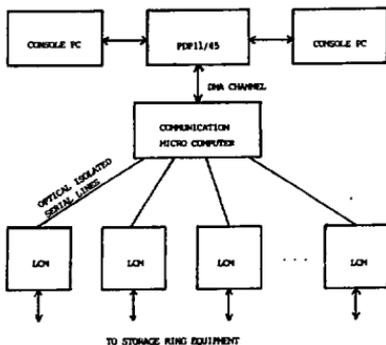


FIG. 4 BLOCK DIAGRAM OF HIRFL RING CONTROL SYSTEM

Because of the local intelligence of the LCMs, direct control and monitoring of the hardware equipments from the main computer are unnecessary. Most of operations are performed by the LCMs, system reliability and speed is improved. This is more obvious for ramping operation. With preloaded ramping table and hardware synchronization, ramping time can be less than 1 minute.

The CMU is a microcomputer specially designed for communication. It is a MULTIBUS system consists of a master CPU board, a DMA communication board and up to 10 intelligent serial communication board. CMU exchanges data with PDP through DMA channel and communicates with LCMs through serial links. Maximum number of channels is 40.

Low cost and convenient optical isolated asynchronous serial lines are used for data communication between the CMU and LCMs.

2. Software

The software for the control system consists of three levels: ROM monitor for the LCMs, communication program and ring control program.

ROM monitor of the LCM micros manages the LCM resources, handles communication and performs various control and monitoring functions.

The communication program includes ROM control monitor for the CMU, DR11-B driver and data buffer manager for the PDP.

The main function of CMU monitor is to handle the data exchange between the LCMs and the PDP. All data are exchanged in records. Error detection and retransmission are

implemented.

The PDP DR11-B driver is installed as a device driver under the RSX11-M operating system and can be invoked by QIO. LCM status informations are stored in a shared data region on the PDP which is accessible by the console PC programs.

Ring control program includes transport line control, ring device status display, ring lattice setting and changing, beam energy ramping process control, close orbit correction and equipment testing programs.

Presently only transport line control, lattice setting, ramping control program and orbit correction programs are executed on the console PCs. Ring modeling, ramping table generation and other calculations are performed off-line.

3. Present status

The system was completed in March 1989 and has been operated since then. During the commissioning period the control system has performed satisfactorily.

Ring magnet control assured stable ring operation.

Ring control programs serve well for injection and ramping process control. But off-line calculation of physics parameters is inconvenient for machine study.

Beam energy ramping control is very successful. With the table ramping technique energy ramping or transfer to different lattice is very easy and smooth. Beam loss rate from 200 MeV to 800 MeV with 200 mA current is less than 7%. This is a good indication of ramping accuracy.

System communication has been reliable. But the response is slow. This is due to the speed of serial lines between console PCs and the PDP. LCMs are reliable and easy to maintain.

4. Upgrading plan

Several problems exist in the present HESYRL control system: 1) Transport line control and vacuum monitoring are now controlled by two standalone PC control system. They are not linked to the ring control system. This is not convenient for system management and data logging. 2) PDP seems unnecessary in the communication system, also it becomes a weak point. 3) Lack of on-line calculation ability is not desirable.

In order to solve the above problems, system improvements are planned.

DECNET will be implemented to link a Micro VAX11, the console PCs, transport line control PC, vacuum monitoring PC and a recently installed VAX6310 system together. This will give us a fully linked system with much expanded computing power.

The PDP computer will be replaced by two BIT3 bus connector cards which connect PC bus to MULTIBUS of the communication microcomputer. This will eliminate the

bottle-neck and increase data speed of the whole system.

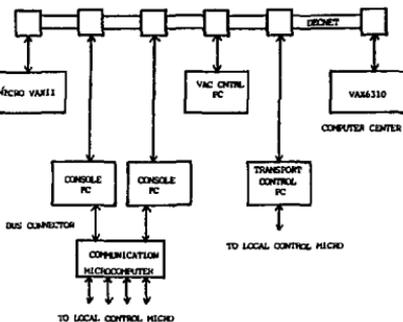


FIG.5 UPGRADE OF HESYRL CONTROL SYSTEM

Console display and computation power will be upgraded by replacing the console PCs with more powerful 386 or 486 stations.

Control programs and system communication programs will be rewritten to include on-line calculation function and node to node communication.

V. CONCLUSION

Started almost in same period, the control systems of the three accelerators are now all in operation. In parallel with the development of the systems, our chinese colleagues have gained experiences and established their qualified cooperative teams. This is a promising start.

Compared with world advanced laboratories our systems are not advanced no matter in architecture, hardware or software. Some system upgrading and optimizing work remains to be carried out.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

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