DESIGN OF NEW CONTROL SYSTEM FOR THE KEK 12 GeV PS

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Introduction

In the past decade, MELCOM-70 control computer system have been running for the 12 GeV proton synchrotron. Recently, unidentified troubles are increasing rapidly. Potential of the system is not enough to create an automatic control system. The LSI technology enables us to create a higher potential system than present one, and the cost of new one is lower than old one. We decided to replace the control computer system with the micro-computer system.

The new system is constructed with VME-bus based micro-computers [1] which are distributed around the accelerator and connected with a local area network. Almost all the system components are commercially available. Power supply interface controllers are located near power supply, and connected to a VME module via a serial bus. A set of touch-panel and character display is used for man-machine interface for easy operation.

A software system is designed for simple and automatic operation using a database system. The fuzzy set theory [2] is planned to be used to try automatic tuning of the accelerators, which is expected to avoid control errors.

The energy of the proton linac will be increased to 40 MeV. A test system for the control device of linac-booster beam transport line will be constructed until the end of FY 1985.

Hardware

A) General description

The VME-bus based computers are used as the controller for the 12 GeV PS. They are located at each local control room and power supply room. A local area network (LAN) connects them. As shown in fig.1, the system is build around the LAN, which is composed of local device control computers, software development computers, operator's consoles, and a LAN server. Load modules of programs are transferred through the LAN from the software development computer to the target one.

At the central operator's console, all of the accelerator devices can be operated. Touch-panels and graphic displays are installed as man-machine interface. A portable terminal can be attached to the local control computer to test the devices locally.

Local computers have VME modules of analog I/O, digital I/O, and homemade power supply interface controller drivers.

The software development computers are a Motorola's VME/10 and a VME-bus computer which is equivalent to the VME/10. Both of the computers operate under multi-user operating system. As the system is composed of modules, the trouble shooting and recovery can be done by replacement of the modules.

B) VME-bus computer

There are many kind of standard buses. The VME-bus board computers are adopted, because of its high reliability of Euro mechanics and abundance of modules made by various manufacturers. The Motorola's I/O channel can also be used.

We use MC68000 family MPUs suitable for our requirements. As the MPU has large memory space, local computers can have large main memory without disc memory. All programs run on the main memory of local computers and operator's console ones. The software is down-loaded through the LAN and is dynamically linked to the real-time monitor. The monitor is also down-loaded by means of initial program load sequence.

A multiprocessor system can be organized if it is required, though the monitor software becomes complex.
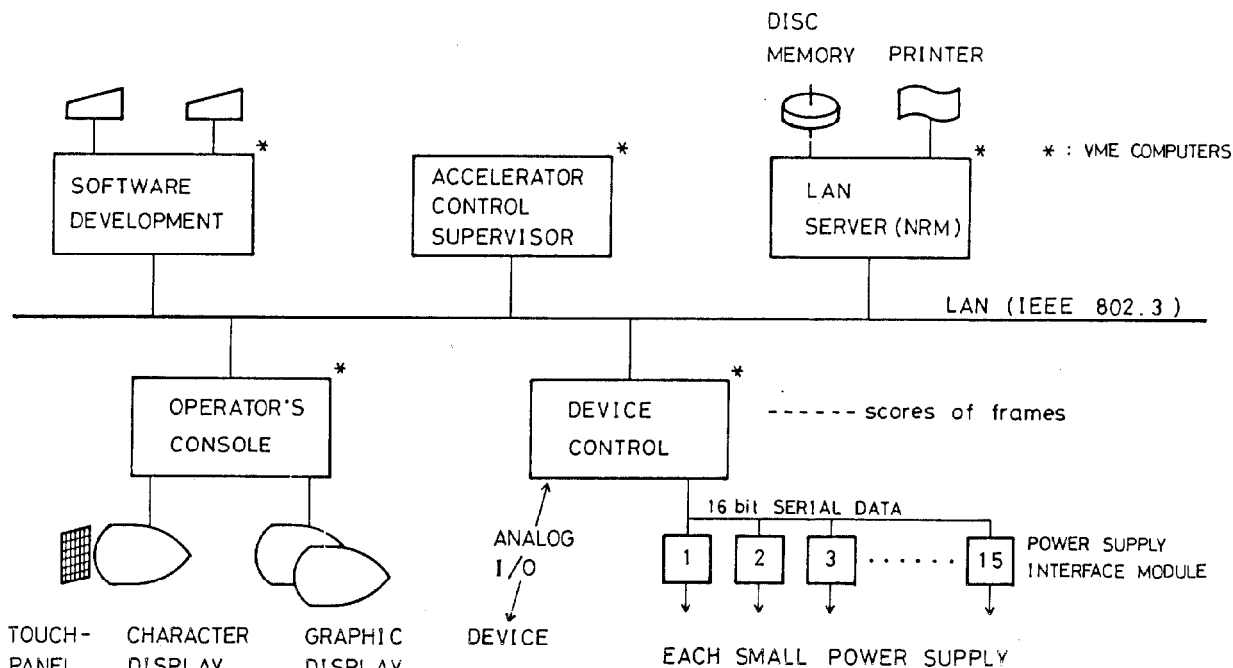

Fig.1 Schematic diagram of a new computer control system.

C) LAN

The LAN links all computers of the accelerator control system. Principal data on the LAN are accelerator information and programs. The accelerator information is broadcast from each computer; device failures, beam intensities, beam energies, the operation mode, and so on. Control commands for the accelerators are also transferred from the operator's console or the supervisor computer to each local computer.

Various LAN's are supplied by many manufacturers. The Ethernet 2.0 (IEEE 802.3) is adopted for our system, because it is a widely used standard and supported by some VME module manufacturers. The data transfer rate 10Mbps is estimated to be fast enough for our system. It is convenient for us to expand the system gradually by connecting the local computer to the network.

As the maximum cable length between computers is estimated to exceed 500m (the maximum cable segment length of Ethernet), two layer construction must be used as shown in fig.2.

works at the operator's console depend on system construction of computer control. If an automatic control system were installed, only "YES" or "NO" keys and a schedule input key-board must be on the console. If otherwise, a lot of man-machine interface are required; such as displays, oscilloscopes, a key-board, and control knobs.

Two sets of touch-panel and CRT display are used for inputs. One is used for menu-selection and the other is command and data input. The touch-panels have been used for operation at other divisions in our laboratory and are found very useful for accelerator operation.[3]

High resolution color graphic displays are used to display the accelerator information such as beam-orbit. The video-information can also be displayed on the same monitor by switching the signal source.

At the local computer, portable computers can be used as operator's console by connecting it to the local computer via RS-232c ports.

Fig.2 Local area network (LAN).

D) Power supply interface module (PSIM)

Each small power supply is connected to a PSIM as shown in fig.3. The PSIM has analog I/O, digital output, status input, on/off, and interlock functions.

Control information is transferred through a twisted pair cable by 16-bit Manchester encoded serial data; 4-bit address, 4-bit command, and 8-bit control values. Fifteen devices can be controlled through a serial cable and under a VME PSIM driver.

As all control signals are latched in the PSIM, the accelerator power supplies are protected from computer power down. Its own interlock system is still alive at that time. All analog signals and digital outputs are opto-isolated between the PSIM and the controlled power supply. The control signal and status are passed through relay contacts for isolation. The serial data transfer line is also isolated by two transformers. Therefore, the computer system is completely isolated from controlled devices.

E) Man-machine interface

It is very difficult to decide what can be done or what must be done from the operator's consoles, because

Fig.3 Power supply interface module (PSIM).

Software

A) Operating System

Computers of this system are divided into two classes. One has hard-disc memory and the other has no disc memory. The software development computer has a Winchester disc memory and their operating system is VERSA-dos with FORTRAN and PASCAL compilers. The LAN server(network resources manager) has large capacity disc memory for common database and printers.

On the other hand, local and operator's console

computers are operated with real-time multi-task monitor (Motorola's RMS-68K) without disc memory. The LAN handler is added to the monitor, which down-loads application programs through LAN and linkes it to the monitor.

B) Accelerator operation

The KEK four-stage accelerator is very complex to operate. Many kind of control devices are distributed around the accelerator. The control parameters are not independent from each other. To manage the complex information of the accelerator, data-base management system is used.[4] The data are computer/device address, conversion coefficients between signal and physical value, operating status, and relations between physical value and accelerator parameters such as beam emittances.

The computers can assist the operator's tuning all of the accelerator parameters using physical values, controlling the power on/off sequences, checking the operating parameters, checking up and collecting the orbit.

LOCAL COMPUTER SOFTWARE
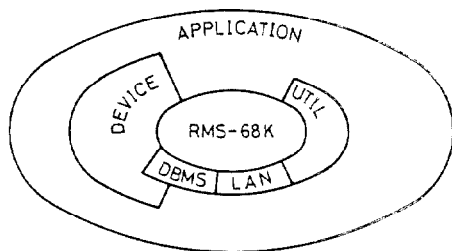
RMS-68K : SOFTWARE KERNEL

LAN : LAN HANDLER

DBMS : DATABASE MANAGEMENT SYSTEM

DEVICE : DEVICE HANDLER

UTIL : SYSTEM UTILITY

Fig.4   Software in local computers.

C) Trial - automatic control

The dream of a control systems designer is to construct an autonomous control system. Though it is easy to start-up and turn off power supplies according to schedules, automatic tuning with analog control requires feedback loop and complex algorithm. Furthermore, there are problems caused by temperature drift , long time drift, irradiated degradation, and so on. Conventional control system has local feedback but does not have total feedback.

Quality factor (QF) of the acceleration is used to check the operating conditions. It indicates that the condition becomes better or worse at all times. The QF is estimated from the beam intensity (average and standard deviation), the beam-orbit, and the beam transfer efficiency at each stage.

Sometimes, feedback loops becomes unstable due to errors. To avoid the instability of the total feedback system, the control system is investigated with the "fuzzy logic" that is such as "almost good but not

complete". The fuzzy set theory enables us to have fully automatic tuning system. The control characteristics are checked by the QF. This method put the accelerator to a good operating point.

Discussion

As the computer system uses the VME-bus, there are some merits; easy grade-up, simple expansion, and localized trouble shooting. This system has more merit that the system do not depend on only one manufacturer. Therefore, module selection becomes widely. The multi-computer system can be made up, if required to this system, which can have common data memory and can do another tasks at same time.

Since a cyclic machine such as a proton synchrotron requires higher speed of responce than it of a storage ring accelerator, a compiler language (FORTRAN) is more suitable than a interpreter one for development of application programs.

At present the dedicated computers for the main ring RF and the magnet power supply are working independently. So those will be linked with the LAN to this system. For total control, all devices at the acceleator must be operated by the control computer.

Equipments of the 40 MeV beam transport line are controlled by the new system. It is the test case of the new computer system. If it works successfully, replacement of the whole system will be done in FY's 1986 to 1988.

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