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CONTROL COMPUTER SYSTEM FOR KEK PROTON SYNCHROTRON

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Abstract

A multi-computer network system is used for controlling KEK proton synchrotron. The system is composed of 8 mini-computers-- a central computer, 6 satellite ones and a software development system. Data of the accelerator are taken by the satellite computers which are distributed around the accelerator and then transfered to the central computer through parallel data link lines. The central computer records these data and displays informations to operators. The softwares for the satellite computers are developed on the software development system or the central computer. Development of the system softwares and installation of hardwares are completed and some applications are running now.

Introduction

The KEK proton synchrotron is composed of 4 accelerators-- a 750 keV Cockcroft-Walton preinjector, a 20 MeV linac, a 500 MeV booster synchrotron, and a 12 GeV main-ring synchrotron, then the data to be observed are generated at various places around those accelerators, at different timings. Therefore, the control computer system is designed as a hierarchy network connected with high-speed data links. A network with 6 mini-computers was the original plan and two more were added later.

One of them is used as the central computer (CC), one is for software development, and other 6 are for the satellite computers (i.e. S-0, S-1, S-2, S-3, S-4, S-5) which perform direct control functions. The central computer is linked with other 7 computers through the computer link units. The satellite computers share in load of data gathering or controlling of the accelerator, namely, S-0 is for the central control desk, S-1 is for the Cockcroft-Walton and the linac, S-2 is for the booster synchrotron, and S-3, S-4 and S-5 are for the main-ring.

Hardware System

General Descriptions

The system is organized with 8 computers (MELCOM-70s) as mentioned above, and the system configuration is shown in Fig.1. CC has 64k words of core memory, a 2.5M words cartridge disc and various peripheral devices for software development, data recording, and information display. The software development system has 32k words memory, a cartridge disc, and other peripheral devices required for program development. This system also has a CAMAC crate for the data link with HITAC-8800 computers of the Data Handling Division of the laboratory.

Each satellite computer has 8k words memory, one or two process input/output controllers, a DMA process I/O controller, and an operator's console with a plasma display device.

The whole computer system is monitored and remotely controlled from the central control room.

Computers

All computers are mini-computers of 16 bits/word with 800 nano-second core memory cycle-time. The maximum capacity of core memory is 64k words. The CPU (Central Processing Unit) has 4 general registers, hardware multiply/divide functions, 16 level interrupts,

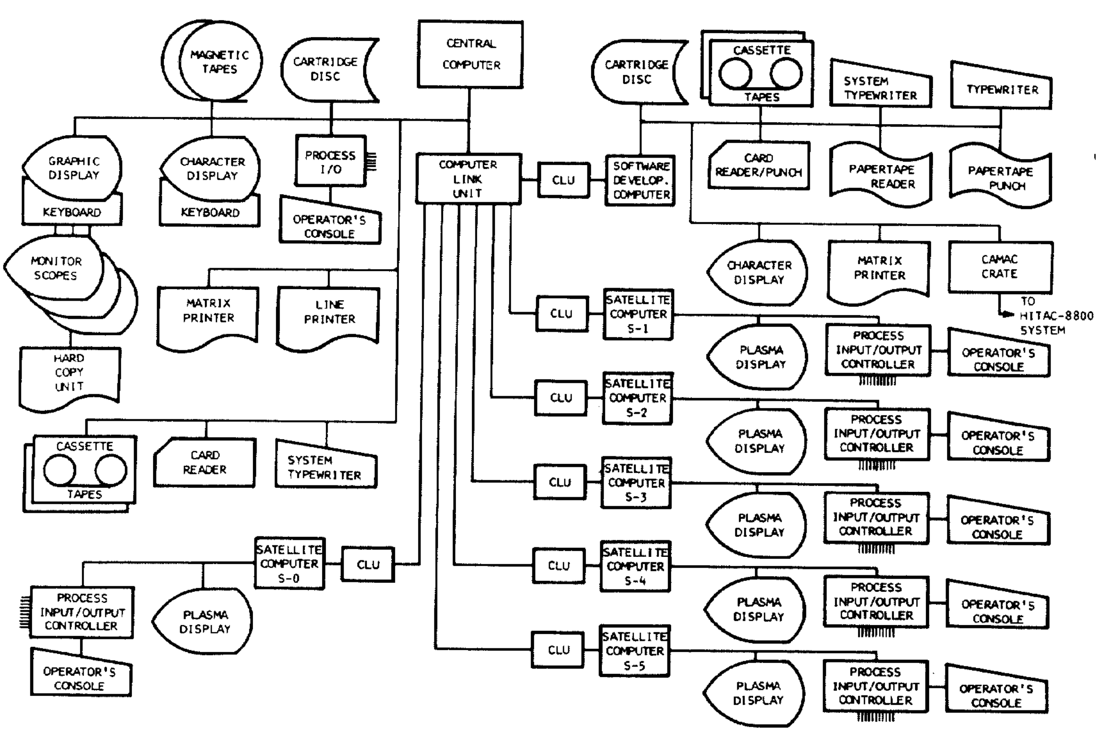

Fig.1 Configuration of KEK PS Control Computer System

auto-increment and auto-decrement counters, auto-indexing counters, a software interrupt, a real-time clock, a watch-dog timer, initial program load, and power fail and auto-restart functions. The central computer has a floating-point arithmetic hardware.

Process Input/Output Interfaces

For an accelerator control system, the computer system should have such functions as interrupt inputs, digital inputs, digital outputs, pulse outputs, analog inputs, and analog outputs. The CAMAC would be a good way to get such a system, but it is expensive in Japan. Therefore, in KEK control computer system, the process input/output system designed for MELCOM-70 computers is adopted.

The process input/output controller is connected to the program controlled I/O channel of the CPU and has its process interface bus lines in the chasis as shown in Fig.2. A printed circuit board unit is inserted into a slot of the crate to connect with the bus lines. Any of different type units such as interrupt input, digital input, digital output, pulse input, pulse output, analog input, and analog output units can be installed in one controller. The process interface units are classified into four groups and these groups can be accessed at the same time; these groups are, interrupt and digital input, digital output and analog output, pulse input and output, and analog input groups. For the digital input and output, three types of signals are available; these are contacts, voltage level signals, and isolated voltage level signals.

Fast signals from the beam emittance monitors, the beam profile monitors, the beam intensity monitors, or the beam position monitors are taken through the DMA process input/output controllers connected to the DMA channel of the CPU. These controllers can be used for input and output of digital and analog signals, and the sampling of data can be synchronized with the external triggers by using the external synchronizing signal multiplexer units.

The numbers of inputs and outputs are listed on Table.

Linkage with the Manual Control System

The control computer system is linked with the manual control system as shown in Fig.2, and at present time, the accelerator manipulation is done mainly by manual and data acquisition is done through the computers.

With the standard control modules (interlock, on-off and up-down modules), the power supplies of various devices are manually controlled, and the digital time delay modules are used for timing control of the pulsed devices. The master clock (1MHz) of the linac and the booster timing is synchronized to the booster magnet cycle. The status of the control modules and the data of the timing control are taken into the satellite computers through the digital input units. The helipot-stepping-motor modules that are driven by the pulses of the up-down modules adjust the outputs of the power supplies. In case of the computer control, the pulse train from the pulse output units drive the stepping motors, and the data of the power supply outputs are collected through the analog input units. In future, the manual control system would work as the backup system of the computer control.

Computer Link Unit

The computer linkage between the central computer and other computers are high-speed parallel data links in half-duplex mode. The data transfer is done by block transfer method and a block is divided into 8-bit parallel signals on the link lines. The check of the data is done by the parity bit of each 8 bits data and by the cyclic redundancy check codes at the end of a block. The transfer rate is 100k words/sec. and the distances between computers are from 10 to 335 meters. The signal lines are isolated at the input port using opto-isolators.

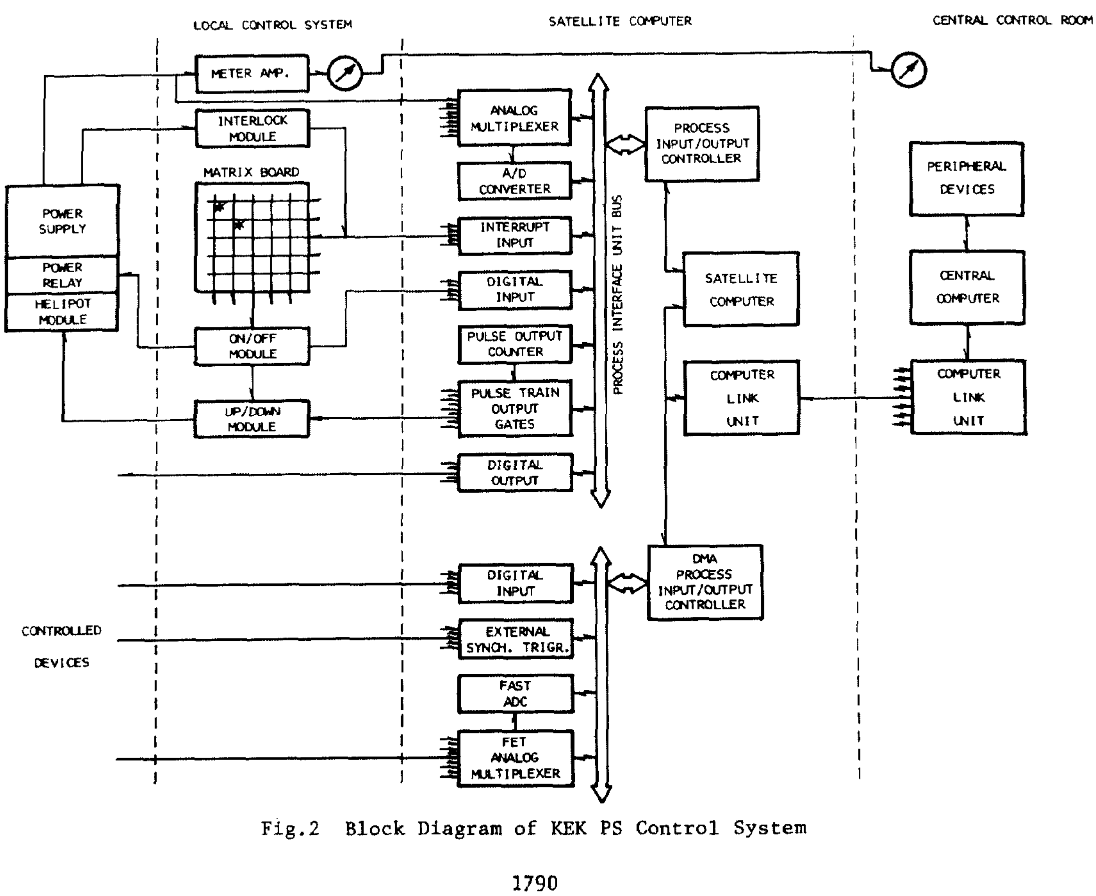

Fig.2 Block Diagram of KEK PS Control System

Table. Number of Process Input/Output Points

Signals		Computer CC	S-0	S-1	S-2	S-3	S-4	S-5	Total
Digital Input	Contact	96	96	96	224	160	320	160	1152
	Voltage	32	192	64	128	32	0	64	512
Digital Output	Contact	8	8	8	40	8	40	8	120
	Voltage	128	128	32	32	64	64	64	512
	Isolated	0	16	0	0	0	0	0	16
Pulse Train Output	Isolated	-	48	128	112	48	48	48	432
Interrupt Input	Contact	32	16	32	32	16	32	16	176
	Voltage	16	0	0	0	0	0	0	16
Analog Input		-	16	256	108	72	120	32	604
Analog Output		0	2	2	4	2	4	2	16
DMA Process Input/Output									
Digital Input	Voltage	-	0	0	0	224	224	0	448
Digital Output	Voltage	-	0	0	0	32	32	0	64
Analog Input		-	48	80	80	48	48	32	336
External Synch.	Isolated	-	8	8	8	8	8	8	48

Software System

Central Computer

The software system of the central computer is based on the RDOS (Real-time Disc Operating System) for a stand-alone system designed by the computer manufacturer, and the RDOS is improved in KEK to adapt to KEK netwrok system. The RDOS supervises 16 levels of tasks and each level can be expanded into 256 sub-levels using a sub-level processor. The RDOS has the foreground/background management function to develop softwares in the background and to execute real-time programs in the foreground.

The improvements have been done on the RDOS for computer communications, memory saving, and for speed-up of the execution. Communications between the computers are done in two modes; one is data transfer mode and another is command transfer mode. In the data transfer mode, the respondent computer can be accessed as an auxiliary memory device. The task control commands or process I/O commands are sent in the command transfer mode and queued in the destination computer to be executed and after processing the reply informations are sent back to the source computer if necessary.

Software Development System

The software system of this system is also based on the modified RDOS and the CAMAC handling softwares are added. Programs written in FORTRAN or symbolic assembly language are compiled or assembled on this computer in the background area, and then, linked output program modules are written on the cassette magnetic tapes to save or to load into the disc of the central computer.

The massages or data to and from HITAC-8800s are sent or received by this computer and transfered to other computers if necessary.

Satellite Computers

The software system of the satellite computers are based on core-resident RTM (Real-Time Monitor) system which handles 16 levels of tasks. The RTM system is reconstructed at KEK for the convenience of the system generations on the central computer or software development system. The whole softwares of the satellite computers are stored in the disc file of the central computer and loaded into the satellite computer at a stroke via the computer link units.

Each satellite computer executes tasks such as, digital data scanning, analog data scanning, data transfer to the central computer, computer communication, operator's console handling, error message transfer, and DMA process input/output tasks.

Operations

The data of the accelerator are taken by the satellite computers and transfered to the central computer after the input data scanning. Therefore, the latest data can be printed out or displayed by the central computer and the data are recorded periodically on the magnetic tapes for later analyses of the accelerator performance.

When an operator wishes to know the informations about the beam, the results of the beam measurements can be observed on the graphic display. Application programs for the measurements of emittance of the pre-injector[1] betatron oscillation frequencies of the booster or the main-ring[2] the main-ring beam position[3] and the main-ring beam profile[4] have been developed.

Conclusion

The control computer system is used for data taking and information display now, and machine operations through the computer system would be developed in accordance with the progress of the machine study and the development of the application programs. New operator's consoles for the accelerator control are now being designed and tested, which use touch-sensitive switch panels and the graphic displays. Some new process I/O interface units such as high-speed ADC and automatic range controlled ADC are under designing.

Acknowledgements

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