CONTROL SYSTEM OF ATF

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Abstract

A computer control system of Accelerator Test Facility(ATF) is described in detail. The ATF presently consists of 60MeV electron injector linac and two klystron test stands, and is controlled by a workstation computer with CAMAC interfaces. For its nature of R&D accelerator aimed to realize TeV region linear collider, the control system also should have a flexibility in both hardware and software. Programmable sequence controllers are introduced in the electron gun system and klystron modulator systems and their performances are tested. The control software which is coded using FORTRAN consists in many independent programs. Each program can access to full functions of a specified device or can control the function which is common to many devices.

Introduction

The ATF has been constructed to stimulate R&D work for the linear collider in TeV region.[1] We completed the first stage of the construction and can proceed R&D programs by using their 60MeV injector linac and two klystron test stands. The injector linac is composed of a 240keV thermionic electron gun, three stage subharmonic bunchers(SHBs), prebunchers and a buncher followed by high gradient accelerating structures. The main control computer is a VAXstation 3500 workstation and the backup and development machine is a VAXstation II/GPX. The interface is a CAMAC system using a serial highway of optical fiber cables, and their interface modules are the same ones used in TRISTAN control system (see Fig. 1).

Control Hardware

Computer

The VAXstation 3500 and the VAXstation II/GPX are 32-bit workstation computers with 3MIPS and 1MIPS performance respectively.[2] The VAXstation 3500 includes a 19" high resolution(1024x864) color monitor, three-button mouse, keyboard, and is equipped with 16Mbytes of memory, a 280Mbytes hard disk and Ethernet. The selection of computer was made because of its useful VMS operating system, efficient program development environment, powerful networking(DECNET) ability and easy installation to the existing KEK network system. The main computer is VAXstation 3500 which controls all equipments of the ATF using CAMAC interfaces. VAXstation II/GPX also has a 19" color monitor, three-button mouse, keyboard, and is equipped with 13Mbytes of memory, a 318Mbytes hard disk. Because of lower CPU performance compared with VAXstation 3500, we use it for program development, test of CAMAC modules and supplemental console for main computer.

CAMAC Interface

We decided to adopt CAMAC system as interface standard. The reasons are

1) We can use many CAMAC modules developed for the TRISTAN control and experience obtained in the TRISTAN control.
2) Wide varieties of CAMAC modules are commercially available, reducing a risk to develop a fully new system.[3]

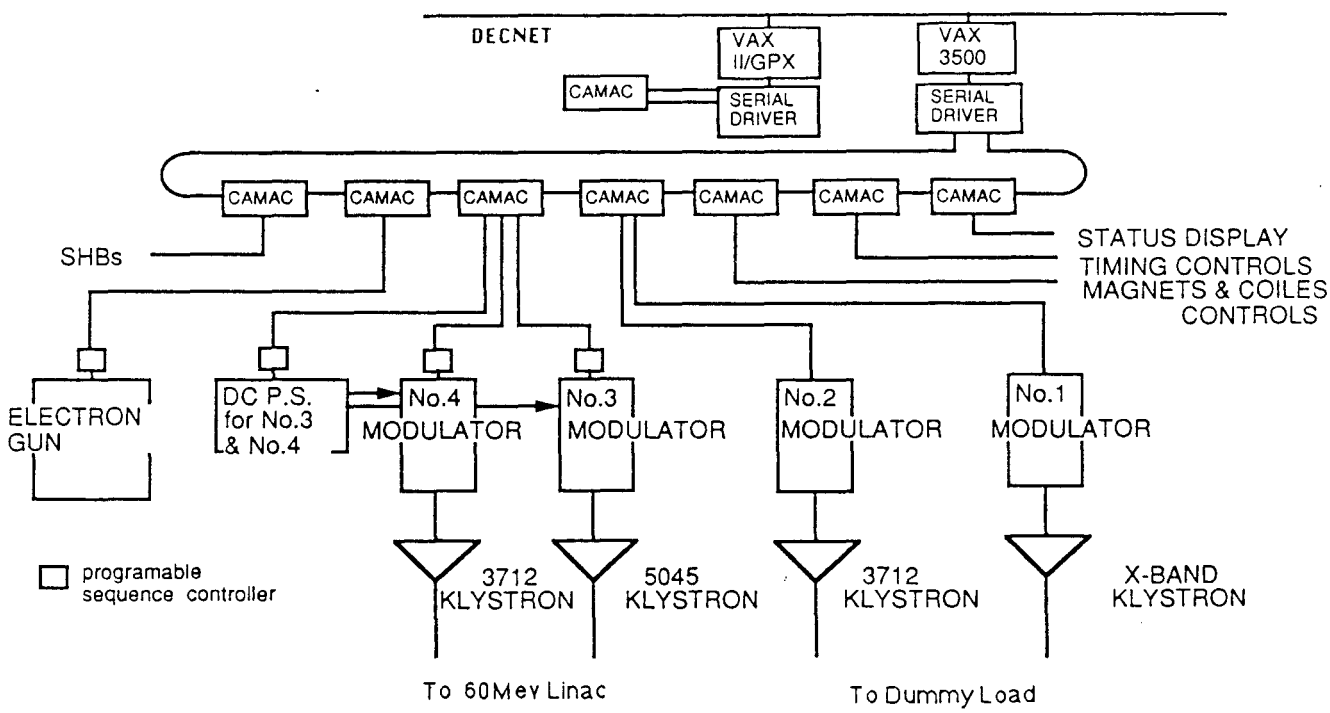

Fig. 1 Computer control scheme of the ATF

The CAMAC system uses 5Mbytes/sec serial highway. Each crate is connected by optical fiber U-port adopters with bypass and loop-collapse functions. Using this optical fiber communication, we can easily extend its distance between the computer and the CAMAC crates without picking up any induced electromagnetic noise. An enhanced serial highway driver(2160-z1f,Kinetic System corp.) is used in the VAX's Q-bus and provides 1.7Mbytes/sec DMA throughput. 7 CAMAC crates are used respectively for klystron modulators No.1 & No.2, klystron modulators No.3 & No.4, electron gun, focusing and steering coils, trigger timing controls, SHBs and various monitors. Each crate is installed in the most nearest place to the device. The CAMAC modules for device control are status input gate(SIG), status output register(SOR), scanning A/D converter(SAD), D/A converter(DAC) and pulse train generator(PTG) which are designed for general purpose use in the TRISTAN control. Several kinds of CAMAC modules from venders are also used in this system.

The basic philosophy of our device control is to keep continuity of control between remote computer control and local manual control. In other words, we must easily take back a control from computer without any discontinuity of operation. In order to accomplish this philosophy, the interface of newly designed device is changed to keep continuity of operation. For example, current setting of a helmholtz coils is usually made by D/A converter from CAMAC and potentiometer from device panel. It has discontinuity of current setting for turning local/remote switch. Then we adopted a single reference current setting generator in the power supply which is controlled upward or downward by pulse from CAMAC module or by pulse from buttons of device panel.

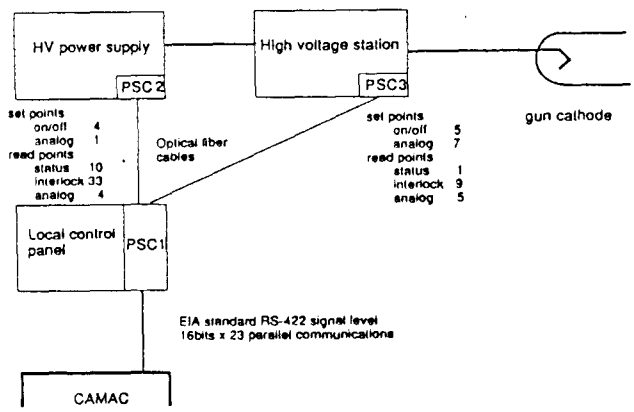

Fig. 2 Programmable sequence controller for electron gun

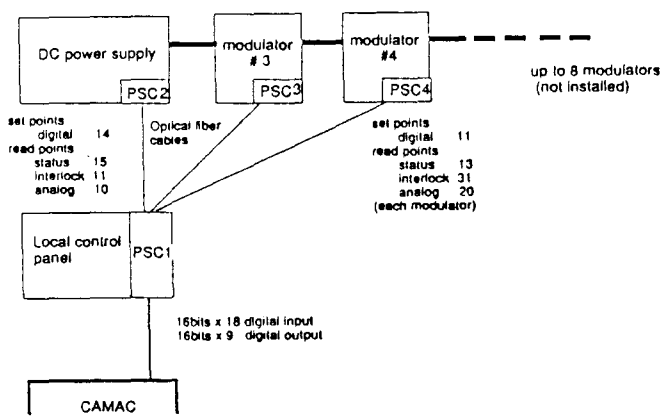

Fig. 3 Programmable sequence controller for klystron modulator

Programmable Sequence Controller

A distributed control system needs to construct a huge and complex control system like the linear collider. Programmable sequence controllers(PSC) are one of the candidate of the distributed control devices. They have CPU, digital input/output, ADC, DAC, etc. and act with high reliability. We adopted these devices to klystron modulators and electron gun system (see Fig.2,3).[4,5] The electron gun system has the modulator of which the behavior is same as klystron modulator. In the figures, when main PSC(PSC1) get commands from CAMAC interfaces or local control switches, the PSC send the commands to target PSC(PSC2,PSC3, . .), located in the hardware, after all PSC's conditions are checked. Conversely when interlocking signals arise in target PSC, the PSC turn concerned devices off and send the status and the kind of interlocking signal to main PSC. Therefore PSC can reduce software load of host computer and simplify the program. In the aspect of hardware, the wires are reduced by target PSC located in the hardware.

These PSC act with high reliability in the hardware. But following two points must be improved mainly.

1)Working speed: about 10 sec. is required for varying 10kv of the de-Qing voltage of Klystron modulators. In this case, the reasons are we don't care about software optimization and the PSC haven't adequate working speed of this purpose.

2)Trouble-shooting: when hardware troubles arise, it is difficult to know the failure source of device, because the signals from the PSC can't be verified by host computer directly.

CATV System

Various informations for operation(operation status, scope signal, beam plofile, local instruments information, etc..) can be viewed everywhere in the experimental hall and control room using the CATV system. At the control room, there are eight 10" TV monitors and one 25" TV monitor which can select and monitor the informations of 11 TV channels allocated in the range of 70 to 250MHz frequency presently.

Control Software

The software has three generation shown in Fig. 4. The lowest generation routines are 2160 VMS CAMAC driver(Kinetic System Corp.). They are strongly device dependent routines which interface to CAMAC serial driver hardware. In order to interface generally to higher routines, we adopted IEEE std 758-1979 routines which can provide us general interface to CAMAC and put it over 2160 VMS CAMAC driver, so that we can easily change interface hardware or computer itself. The next higher level routines are device handlers which control a function of a device such as LV switch, HV switch, trigger switch of a klystron modulator etc.. These routines are FORTRAN Function type programs. There are two types of function for each hardware device. One is a controllable function, we can read its status and write control to the device. The other is a only readable function, for example reading cathode voltage, beam current of a klystron etc.. We use FORTRAN Function routines for controllable functions, and for readable functions. Also Subroutine routines are used for group reading at one time for readable functions. The higher level programs interface to operators are constructed by device handlers. Their programs generally display the status of devices repeatedly. Operator can interrupt displaying and can issue an command that controls the device. The use of VT-type

character display screen is for aiming of the use of various kind of terminals such as workstations, VT-series terminals, personal computers, portable computers. We also used bit-map color display of the workstation as a graphic terminal for data plots and visualization of status. These device control programs are made for electron gun, klystron modulators, focusing coils, trigger timings and phase/amplitudes of prebunchers and buncher, klystrons and SHBs. Status display programs are also in the same level. They can display the klystron status repeatedly on monitor TVs. We can operate each control program watching the monitor TV.

Operation

In the ATF, various experiments are performed, such as electron gun test and conditioning, klystron test and conditioning, test of high power devices, high gradient experiments and injector study with beam.[6] In order to cope with these experiments, we need a simple control program rather than smart, complicated and automated operation program. So we made programs which control a device or some kinds of function separately. Those programs perform each test and conditioning of device individually at same time. When we use those programs together with, we can operate a accelerator as a whole. A workstation is adequate terminal for that purpose by using its multi-window ability. By this program construction method, we can use these programs not only from VT-terminals near devices but from terminals via network without any expensive console.

Summary

This control system has worked without delay after the installation of hardware devices and contributed greatly to the ATF R&D. Especially it's effective at continuous controlled operation(cavity conditioning, electron gun's cathode activation, etc.). The PSC are useful in this system. But more careful design and trouble-shooting tool(for example PSC behavior monitor) are required. At next step, we would like to research new interfaces(VME, etc.), network system and others.

Acknowledgments

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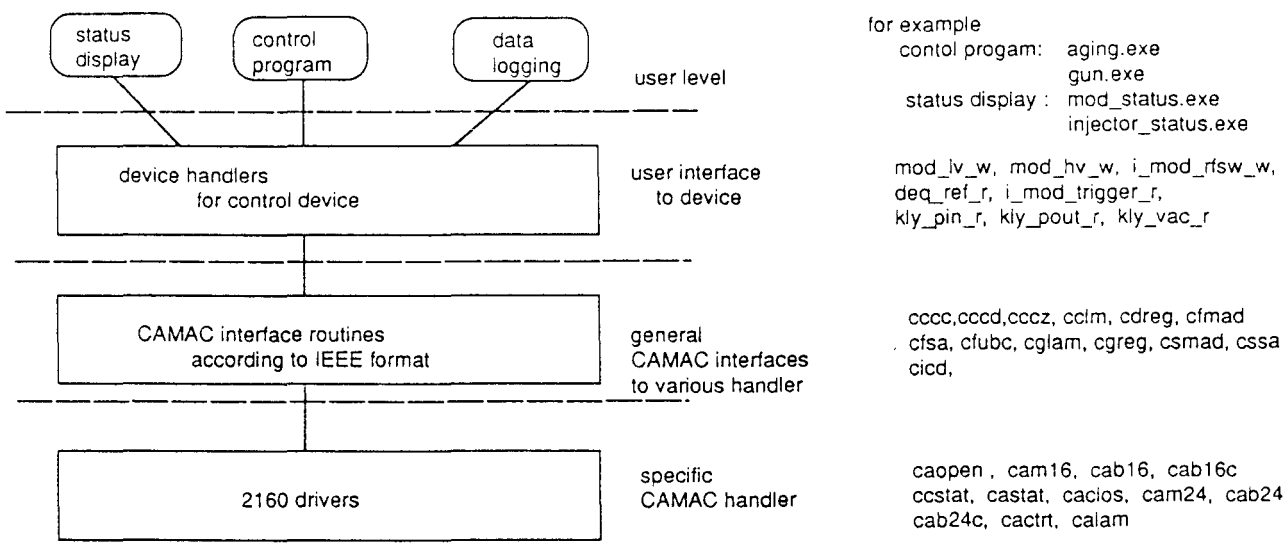

Fig.4 ATF Control Software Structure