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CONTROL OF BEAM LINE MAGNETS BY THE CAMAC SERIAL HIGHWAY

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ABSTRACT

A computor control system of magnets in the low energy separated beams in KEK is reported. The system consists of five CAMAC crates and a central mini-computor. The CAMAC crates are connected by a CAMAC Serial Highway. The transmission is 128 k bytes/sec byte serial mode. Compared to the manual remote control arrangement, improvements in beam line operation can be identified.

INTRODUCTION

As experiences have been accumulated in many high-energy laboratories[1-3] as to the computor control of beam lines and accelerators, the effectiveness of the computor control has become well recognized. By the way, primary and secondary beams in the National Laboratory for High Energy Physics (KEK) had been operated manually; we decided to make a computor control system for the newly constructed low energy kaon beam lines, K2 and K3.[4] The system has been completed in October 1978 and is now working with no trouble. This report describes the detail of the system.

GENERAL CONSIDERATIONS

The final goal of the system is to control the whole primary and secondary beams in KEK by computors. From the point of view of the final stage of the system, there are some items to be considered. First, the number of the beam lines will be more than ten and that of the beam line magnets will be more than one hundred. Moreover, in order to control the beams effectively, it is essential to get real time informations as to the beam characteristics. A mini-computor with, for example, 64 k words memory cannot handle such a heavy task; several mini and micro computors should be used to share the burden. The linkage between these computors will be inevitable. Second, the beam lines are frequently replaced or modified, or newly constructed according to the need of the experiments. The control system of the beam, therefore, should be flexible in order to adapt itself to the future modifications. To attain flexibility, the system should be based on the some standard and also should be composed of modular electronics. Third, the beam lines in KEK are dispersed around several hundred meters. To cover such area, the serial communication is better from the economical point of view.

Taking into account these items, we have decided to use the CAMAC Serial Highway.[5] In the present stage of our system, the CAMAC Serial Highway only acts as a communication line between CAMAC modules in the remote crates and a central mini computor. In the future extension, it can be used as a linkage between distributed intelligent computors in the remote crates.

DESCRIPTION OF THE SYSTEM

The K2 and K3 are low energy separated kaon beams which transport secondary particles produced at external target stations to experimenters' targets. The K2 (K3) has 13 (11) beam line magnets and its associated power supplies. The items to be monitored and controlled are the status of the magnets and power supplies, and the current of the magnets supplied by its power supplies.

Figure 1 shows the block diagram of the system. As is shown from the figure, the system consists of a central mini computor HIDIC-80 with its peripherals and five CAMAC crates (crate 0, 1, 2, 3, 4). The crate 0 is connected to the computor via a dedicated type crate controller (DCC). In this crate a serial highway driver (SD) and a back-up auxilliary crate controller (ACC) with a 8080A microprocessor are installed. The crates 1, 2, 3, and 4 are connected by the CAMAC Serial Highway to the SD. The crates 1 and 2 contain modules which control and monitor the power supplies of K2 and K3, respectively. In the crates 3 and 4, interface modules between the CAMAC dataway and experimenters' consoles are installed. The detailed description of the system are given in the followings.

The magnet power supply contains a 4-digit counter, and a digital-to-analog converter (DAC). The content of the counter can be incremented or decremented by external pulses; the output of the DAC is proportional to the content of the counter. The 9999 count corresponds to 9.999V DAC's output. The output current of the power supply is proportional to the DAC's output.

Three types of CAMAC modules are used to control and monitor the power supplies. (1) A power supply interface module (PSI/F) interfaces between a power supply and the CAMAC dataway. It contains a up/down counter, a preset counting register, a 3-bit input gate, and some reed-relays. The preset counting register can be loaded via the CAMAC dataway and pulses are sent out to the power supply untill the content of the register becomes zero. The total number of the pulses is registered in the up/down counter. The reed-relays are activated by CAMAC commands and make the power supply ON, OFF, or RESET. The input gate records the status of the power supply and the magnet. (2) A 12-bit analog-to-digital converter (ADC) and a 15 channel relay multiplexer monitor the output voltage of the direct current transformer of the power supply. In order to reject common mode noise and to protect against ground loop problems, an isolation amplifier is provided in the ADC. In the relay multiplexer, switching is accomplished with mercury wetted relays to ensure low thermal offsets.

The CAMAC Serial Highway of the system is 128 k bytes/sec byte serial one. The serial driver (SD) of the system is a three-wide CAMAC module inserted in a crate 0. At the present stage block transfer capability is not provided. To incorporate the block transfer capability, it is only necessary to add a block transfer controller and a FIFO buffer. The serial crate controller is a double width type L-2 one that provides the interface between the CAMAC Serial Highway and the CAMAC dataway. It fully complies with the CAMAC specification IEEE 583 and 595. The total length of the Serial Highway amounts to 500 meters.

In order to transmit signals over such distance the standard D-port signal is transformed into bi-phase signal via U-port adapters. A loop-collapse and by-pass capability is provided in the U-port adapter.

At the experimenters' container, a CRT with keyboard is set, which serves as an experimenters' console of the system. The CRT contains a 8080A microprocessor, PROMs, and RAMs. Only legal commands are accepted by the program stored in PROMs; hence protecting the system from the mis operations of experimenters. Experimenters can make the power supply ON or OFF, and set the current of the magnet at any desired value from the keybord. At the end of these action, messages are sent and displayed on the CRT. The linkage between the CAMAC dataway and the CRT is made by an I/O interface module installed in crates 3 and 4 located in the experimenters' container.

The central computor of the system is HIDIC-80.[6] It has 16-bit 32 k words core memory. It is a process control computor and is very reliable against severe environment. As peripherals, it has an ASR-33, a paper tape reader, and a color CRT with a keyboard. The color CRT not only displays the status of the power supplies but also acts as a console of the system operators. The video output of the CRT is splitted and transmitted via 50-ohm coaxial cables to the experimenters' container, where it is displayed on monitor TVs. The computor is connected to the CAMAC system via a dedicated type crate controller (DCC) in the crate 0. An auxilliary crate controller (ACC), which contains a 8080A microprocessor and some IC memories, is placed in the same crate. When the central computor is down by some reasons, the ACC backs up the whole system. Due to the small size of the memories in the ACC, the control capability is somewhat restricted, nevertheless, the system is still working with practical no loss time.

The operating system used is the core only version of PMS (Process Monitor System) delivered by the manufacturer. PMS is an on-line real-time monitor with multi computor programming function, designed to achiev the maximum possible overall efficiency. By PMS, user's work is controlled by the unit of "task", and the program execution sequence and the hardware operation are controlled and monitored.

The CAMAC handler is composed of the PMS connection section which receives Transmit/Receive request information from user's programs, and of the transmission control section which performs CAMAC Serial Highway control upon the CAMAC command sequence. The CAMAC handler provides the basic access macros required for communication control so that applications best-suited for user's purposes can be realized where high real time capabilities are required.

Application programs are devided into five categories. They are: (1) Tasks which monitor the status of power supplies every five seconds, (2) tasks which monitor the current of power supplies every 15 sec, (3) tasks which control the status of power supplies (ON/OFF), and set the current of magnets at any desired value, upon requests from experimenters, (4) tasks which control the man machine interface between system operators and the colour CRT, (5) tasks which make the CAMAC Serial highway, power suplies and the CRT at initial status.

CONCLUSIONS AND FUTURE EXTENSIONS

Compared to the manual remote control arrangement which has been in use at KEK, some improvements in beam line operation can be identified.

(1) The time needed to exite the beam line to some predetermined value is reduced from 30 minutes to two or three minutes.

(2) The occurrence of trips of the power supplies due to mis operations of experimenters completely disappears.

(3) The checking of the beam line status is done every five seconds, which ensures the stable operation of the beams.

(4) Every failures of the beams and the system are recorded on a typewriter, which greatly helps the maintenance.

As a future extension of the system, we are planning to add disks to the HIDIC-80 to increase the control capability of the system. In addition to it, auxilliary crate controllers with microprocessors are to be installed in remote crates to facilitate the local processing of the system; it will lessen the burden of the HIDIC-80. The block transfer capability will be added to the SD, which will decrease the number of transactions on the CAMAC Serial Highway. With these modifications, the system can easily handle more than ten beam lines with satisfactory speed.

References

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6. HIDIC-80 is made by Hitachi, Ltd. Japan

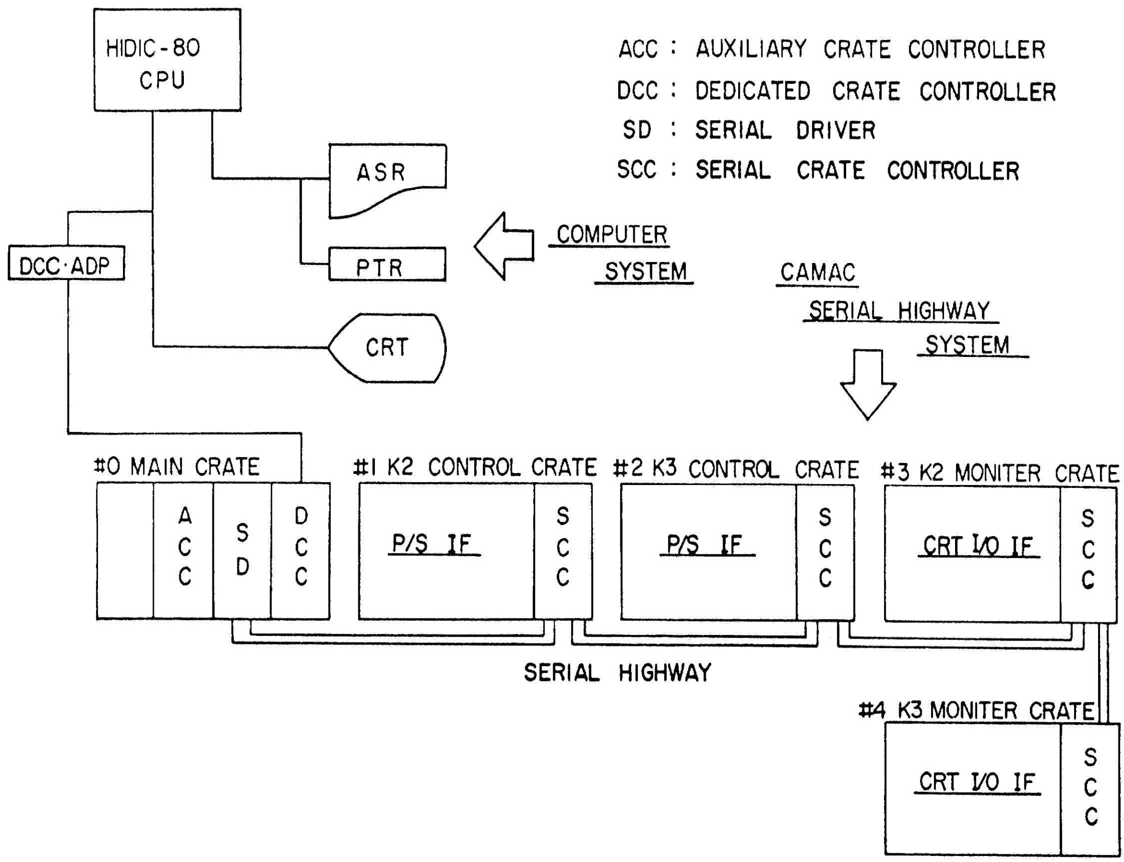

Fig. 1 Block diagram of the system