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CONTROL SYSTEM OF BEAM LINE MAGNETS IN KEK

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SUMMARY

A computer control and monitor system was constructed to handle power supplies of the beam line magnets. The interface modules are installed in CAMAC crates linked by a CAMAC serial highway. The structure and performance of the system are presented.

INTRODUCTION

The fundamental motivations of our adopting fully computer-controlled system are:
1) The number of magnets in the beam line is too large to be managed successfully, by a few person in charge, in traditional direct inspections.
2) Because the secondary beam lines may be operated in an open-shop system, a complete protection for mishandling should be provided and the operation method must be easily learned.
3) The real-time centralized monitoring of the power supplies and magnets will attain a high availability because of quick detection of the troubles.
4) The operation diaries are kept systematically and automatically in this system.
5) The expansion of the system can be performed in the same principle with a well known and evaluated method.

The prototype of the system[1], which supported beam line magnets in the K2 and K3 beam[2], was completed in Oct. 1978 and was successfully drived for a year. In 1979, the system was graded up to control all the beam line magnets in the slow extraction beam channels and their associates.

The principal functions of the system are;
1) to monitor and log the magnet/power supply status,
2) to display the magnet/power supply conditon on a TV screen, and
3) to control the power supplies according to the commands from CRT terminals in the accelerator control room or in the electronics stations of the physics experiment.

The characteristic feature of the system is that the system is constructed fully due to the serial CAMAC standard specification[3] to interface destination devices to the computer. A CAMAC interface, specially designed dedicated type crate controller, was developed and extensive softwares were implemented to handle the serial CAMAC system.

CONTROL SCHEME

In order to interface power supplies to CAMAC, a PS-interface, specially designed CAMAC module, has all the necessary functions to control the power supplies. The control signals to the power supplies are transmitted as a non-voltage relay contact signal; attaining a high performance without any annoyance in the noisy environment. The current output is adjusted by a 12 volt pulse train. Each power supply has internally an up/down digital counter with a maximum count of 9999 or 4095 in decimal. The digital count is converted into an analog reference voltage by a specially designed high precision DAC which attains a good reproducibility/stability of an order of 10^{-5}. The overall control scheme between an operator and the power supply is illustrated in Fig. 1. A control command entered from a CRT terminal is processed by the control computer, then the computer issues an instruction to a certain PS-interface. The completion of the command is acknowledged through the TV status display or a response to the CRT terminal.

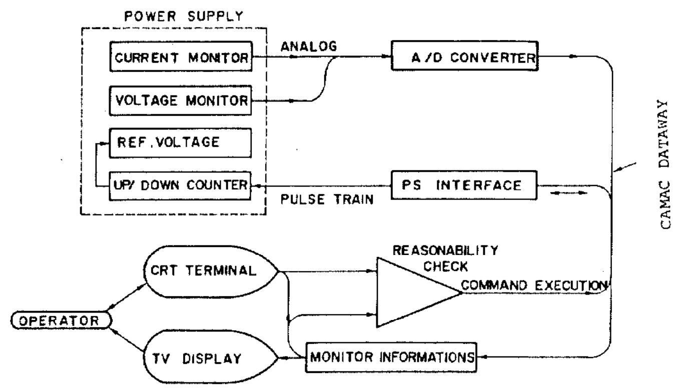

Fig. 1 Control Scheme

COMPUTER SYSTEM

The control system is managed by a HIDIC-80 computer system, a powerful 16-bit computer, developed by Hitachi Co., Ltd, Tokyo, Japan in 1975. In KEK, the HIDIC-80 system is already applied as a principal controller of the KEKNET[4], a high capacity data transfer system.

The main storage has a capacity of 64 k words in maximum, which can be accessed in 650 nsec for a magnetic core memory. A special CAMAC interface is provided to give a complete interface between the HIDIC-80 computer and a CAMAC crate throuhg a full-duplex DMA channel. Beside of the program transfer, three block transfer modes are implemented; the address scanning mode, the repeat mode and the stop on word mode.

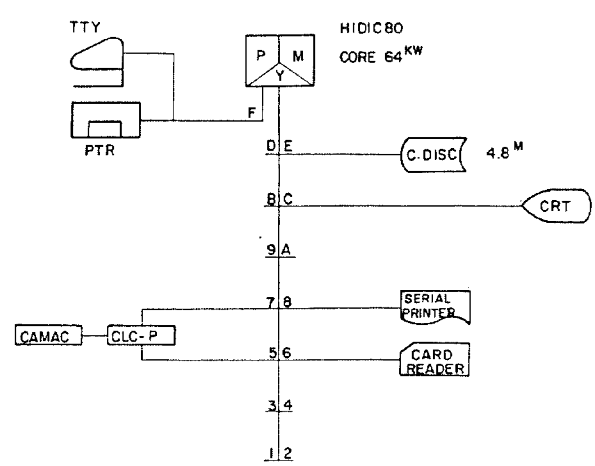

Fig. 2 Computer System

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The maximum transfer capacity is 512(24 bit) words for a block transfer with a DMA capacity of 1.3 M words per second. In Fig. 2 the componets of the HIDIC-80 computer system are shown together with the I/O devices.

SERIAL CAMAC SYSTEM

The serial highway starts from the experimental hall, extending to the accelerator control room via two power supply stations and two electronics stations of the physics experiment. The data transfer rate of the serial highway is 128 k bytes/sec in a byte serial mode. U-port adapters are used to drive cable signals and to provide such functions as bypass and loop-collapse. The geometrical view of the serial highway system is shown in Fig. 3. The serial driver is installed in a CAMAC crate which is in a direct slavery of the HIDIC-80 computer. The function of the serial driver is intensified by a block transfer controller and a FIFO buffer. Beside this crate, there are nine crates under control of the serial highway system. These crates are separated into three categories; a Video-RAM crate, a power supply monitor crate, and a power supply control crate. The actual installations of the modules are illustrated in Fig. 4.

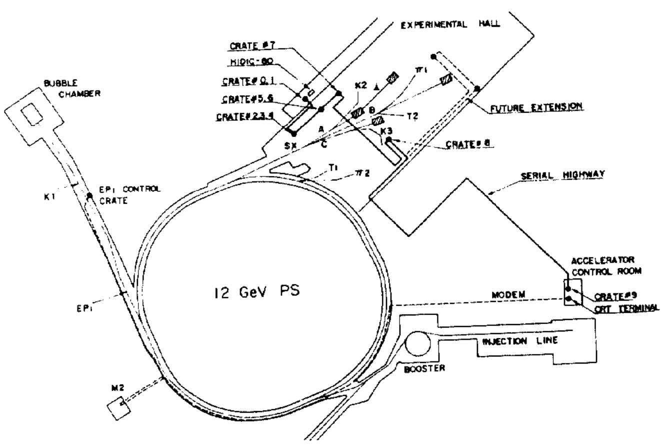

Fig. 3 Geometrical View of the Serial Highway

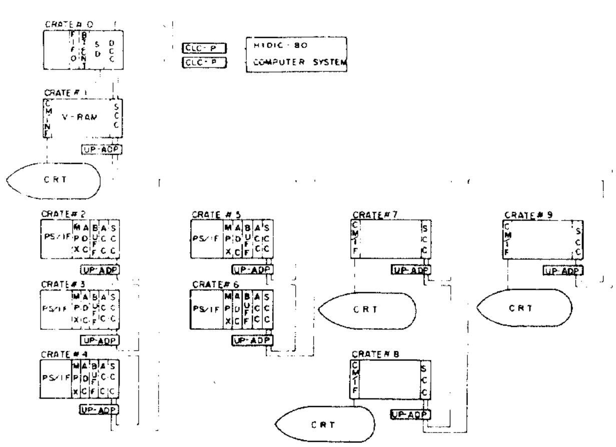

Fig. 4 CAMAC Modules in the Serial CAMAC System

Seven Video-RAM modules are installed in the Video-RAM crate(crate#1) to display the informations about the beam line magnets and the power supplies for each predetermined block of the beam line. A communication interface, which is connected to a CRT terminal, is also a member of this crate. The CRT terminal has an intelligence controlled by an Intel 8080A micro-computer. The CRT can be accessible to limited domain of the power supplies, in order to protect an unwilling interference with the other beam line elements.

The power supply monitor crate(crate#7,8, and 9) has a communication interface only except a serial crate controller with type L-2 functions and located in the user's station.

The power supply control crate(crate#2,3,4,5, and 6) has 15 power supply interface modules in a full installation, two relay multiplexer modules, an ADC module, a CAMAC auxiliary crate controller, a buffer memory and a SCC. The monitoring informations are once stored in the buffer module and read into the HIDIC-80 computer in a block transfer mode of the serial highway system. The acquisition of the monitor information is controlled by the auxiliary crate controller with an intelligence of the 8080A micro-computer system. The software of the ACC was developed by the Intel MDS 220/230 system and planted on the ACC as PROM's.

CAMAC HANDLERS

An extensive CAMAC handling routines were implemented on an online operation system of the HIDIC-80 computer. The operating system is called as PMS and widely applied in the industrial process control system. Through the present CAMAC handler, every application program need not take care of the existence of the CAMAC serial highway and an I/O electronics, such as the dedicated crate controller and serial driver, between the front-end CAMAC modules and the computer. Error handling and the busy management of the CAMAC system are also important role of the CAMAC handler.

The main functions of the CAMAC handler are;
1) CAMAC I/O control,
2) demand interrupt control,
3) management of the communication error on the serial highway,
4) initialization of the CAMAC system, and
5) provision of the debugging and trouble shooting tools.

The internal structure of the CAMAC handler is illustrated in Fig. 5.

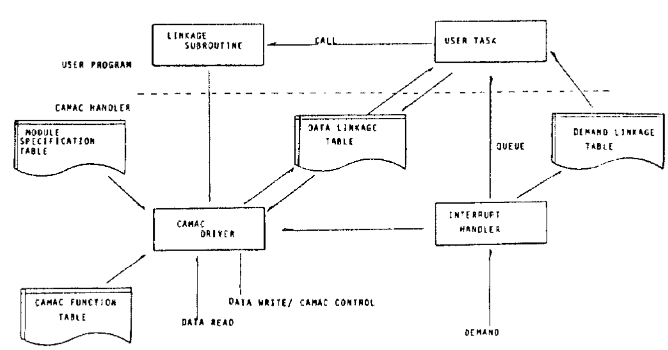

Fig. 5 CAMAC I/O Control Scheme

APPLICATION SOFTWARE

In order to describe control procedures, we mainly used SPL(Software Production Language), which was developed in Hitachi according to the structured programming concept[5]. The distinct features of the SPL language are;

1) Because the source lists of the SPL language can be followed sequencially in a Top-To-Down manner, the logic of the program is clearly revealed; substantially reducing a struggling situation of debugging.

2) Besides the procedure parts, the variables/contants are also constructed in a hierarchy fashion called as Environment. The contents of the Environments are checked prior to the compilation of the procedure part ; reducing a meaningless retrial of the compilation.

The application softwares can be devided into a few categories according to the origin of the PMS request. They are:

1) A task activated by a non-periodic demand which may be a CAMAC demand originated by an operator's console or a request from a basic I/O device.

2) A periodically activated task; a monitoring task and a logging task belong to this category.

3) A quasi-periodic task; for example a complicated sequence control task for the system starting-up/shutting-down routine belong to this category.

The available core area for the application tasks is about 24 k words; they are devided into eight blocks and each task is assigned one of these core blocks or more with an appropriate priority level.

CONCLUSIONS

When the present system is compared with the traditional manual-remote-control system with push-bottons and analog current/voltage meters, some great improvements are revealed in the beam line operation.

1) The starting-up time to settle a group of the beam line magnets to some predetermined power state is sufficiently reduced from 30 minuites to a few minuites. The shutting time is also greately reduced. The possibility of the quick starting-up encourages the experimenters to leave their beam line magnets at minimum power state when the beam is vacant.

2) Because the beam line parameters of well tuned states are registered in the storage of the computer, the beam line tuning can be furnished in less time and in more reliable manner than with the manual controls.

3) The maintenance of the beam line can be performed more effectively than before. Every failure of the beam line magnets/power supplies is recorded on a high speed printer and at the same time reported to the operators through a CRT display and/or a TV screen.

4) The quality of the experimental performance has been improved. The operation of the beam line magnets is fully opened to every experimenter with little aid of a person in charge. A simple beam handling, even in the primary beam lines, may be responsible to the experimenters.

5) The system can be expanded in a homogeneous fashion. When the system is expanded, there will be little modification in the hardware/software configuration of the system. The modifications necessary are to add CAMAC crates and modules, stretching the serial-highway further, and updating several parameter tables in the computer.

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REFERENCES

[1] S. Kurokawa et al., IEEE Trans. NS-26(1979)3325
[2] H. Hirabayashi et al., IEEE Trans. NS-26(1979)3191
[3] IEEE Std. 583-1975 and 595-1976
[4] Y. Asano et al., Nucl. Instr. & Meth. 159(1979)7
[5] W. E. Dijkstra et al., Structured Programming, Academic Press(1972)