LOCAL COMPUTER SYSTEM OF TRISTAN RF

H. Hayano, E. Ezura, T. Takashima and M. Suetake
National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken 305, Japan

Abstract

A local computer system used for conditioning of cavities and logging of RF device status is described. The system consists of one workstation and three distributed mini-computers which can access CAMAC crates by serial auxiliary crate controllers (ACC). These computers are connected by Ethernet local area network.

Introduction

In the TRISTAN Main Ring, the RF system is controlled by two HIDEC 80-M computers which are organized by KEK NODAL system and 80-M network.[1] Operators in the center control room can control, by the touch panels, on-off-reset of low-level RF switches and klystron power supply switches, and settings of reference voltages for various feedback loops. For the RF system, conditioning of the cavities and logging of the RF device status are needed to get stable operation of the system. To perform these functions we have introduced the four MicroVAX computers which have multi-tasking ability and powerful network system. The interface to the RF devices is done by serial ACC in the CAMAC crates which is under the control of 80-M's(Fig. 1). A serial driver and a serial ACC are developed in order to access to the distributed CAMAC crates from the MicroVAX. A device driver software is also developed, so that each task can access to CAMAC without collision with other tasks. The four MicroVAX are organized by the software "DECnet" using Ethernet Local Area Network.

Local Computer and Network System

The CAMAC crates and modules which are connected to the RF devices are installed at local control rooms located both sides of four colliding experimental halls. Each of three local computer MicroVAX II is located at one side of a hall and controls the CAMAC crates in both sides. Now there is no computer at the Nikko area, because this area is for superconducting cavities to be installed in 1988. A computer for Nikko area will be introduced according to a schedule of the superconducting cavities. As a workstation for developing programs and editing the logged data, a VAXstation II is installed at center control room.

Each MicroVAX II has 8MB memory, 71MB disk, 95MB

tape drive, two 800kB floppy disk drives and 8-line serial interface. In order to control the CAMAC serial driver there are two DMA circuit boards (DRV-11WA) and an Ethernet controller circuit board (DEQNA) in the Q22 I/O bus. There are two remote terminals and one serial printer in each local control room, and one remote terminal in each klystron hall.

An operating system software "MicroVMS" is used, and it controls multi-tasking scheduling. In the cavity conditioning time, about fifteen tasks are created and running under this operating system, and the response of tasks is lowered slightly, though it is not a serious problem.

The distributed three MicroVAX II and one VAX-station II are connected by Ethernet hardware and organized by "DECnet" software. The configuration of this network system is shown in Fig. 2. The network consists of four Ethernet cables, four optical fiber cables of about 1 km long each and eight buffered repeaters which allow to extend node separation to well over 1 km. One of the repeaters installed in Nikko area is usually switched off and will be joined the network in case of troubles of other repeater or optical fiber link. By this network, one can become a local user of the remote node and perform local functions such as CAMAC actions. Accessing files on remote nodes and task-to-task communications across the network can also be performed.
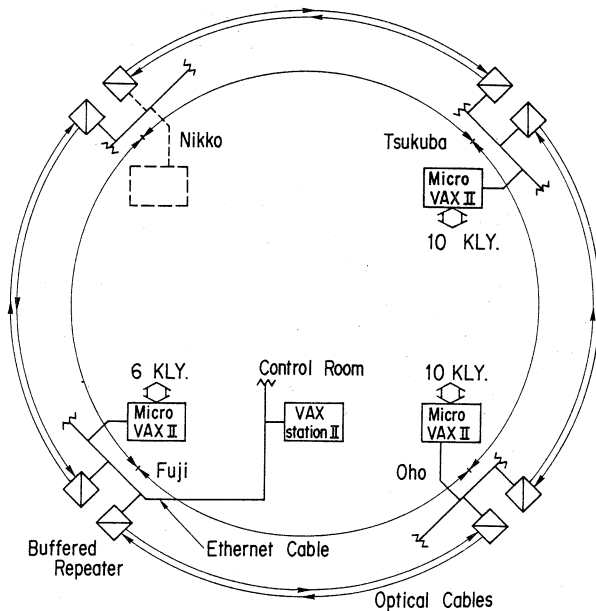

Fig. 2   Network system of local computers.

CAMAC Interface System

In order to connect between the CAMAC crates and the MicroVAX without changing 80-M's hardware, we developed and installed the serial driver and the serial ACC which are able to communicate with the distributed CAMAC crates. In this system is used the encoder/decoder IC of MIL-std. 1553B which can creates manchester codes of 1 Mbps and can convert it to parallel data. We adopted two serial line connection for future distance extension by optical fiber. A twisted pair cable with shield is used in serial line, and the ACC are connected by multidrop method using isolated transformer coupling. A twisted pair cable RG-108/u which is thin and has 32 dB/km loss at 1 MHz is
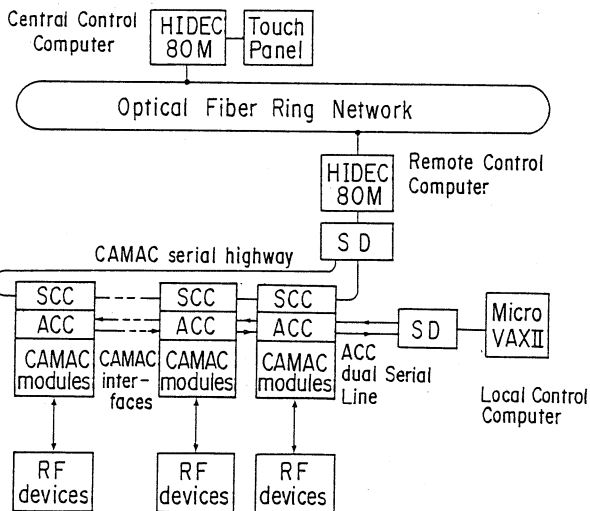

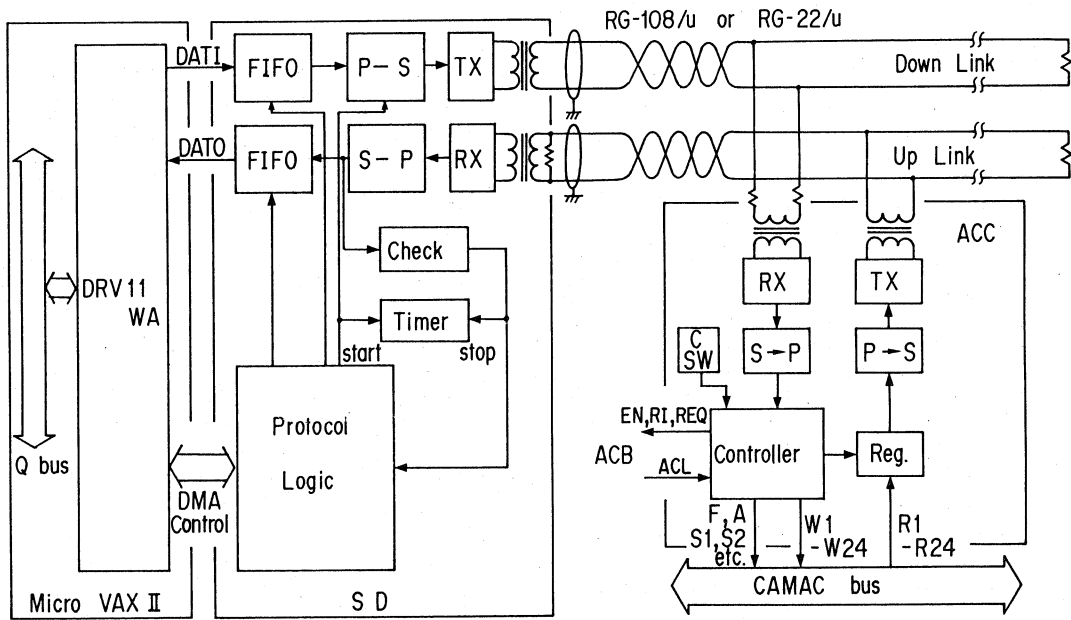Fig. 1   Block diagram of computer-CAMAC interface.

Fig. 3 Block diagram of serial driver and serial ACC.

used among neighboring crates. In the long distance part, a RG-22/u cable which has 9.5 dB/km loss at 1 MHz is used for low loss transmission.

Fig. 3 shows a hardware block diagram of this CAMAC interface system. A time chart of a CAMAC access sequence in this system is shown in Fig. 4. The sequence is as follows. Command words for single CAMAC action consist of three 16-bits words, and C,N,A,F,DH,DL are encoded in it. In the case of multiple CAMAC action, command words will be a set of successive single CAMAC action commands.

The command words in a user program are transmitted to a FIFO buffer in the serial driver by DMA transfer which is controlled by DRV-11WA. A size of the FIFO buffer is 512 words, so maximum allowable number of CAMAC action for single DMA transfer interruption is 170. A protocol logic controller in the serial driver initiates a conversion of the first three words to serial data, and then transmits it to a down-link serial line by a command from device driver software after completion of DMA transfer interruption. The format of the serial data is shown in Fig. 5. Each word has heading SYNC signal, 16 bits serial data, and trailing parity bit. All ACC connected to this serial line check whether a "C" data in the transmitted words coincides with a preset "C" number or not. An ACC which has coincident "C" number receives the three words and converts it to the parallel data. After execution of the CAMAC action specified by received data, the ACC converts the results to three serial data and sends it back to the serial driver using an up-link serial line. A T1 bit and a T2 bit in a transmitted data from an ACC represent a time-out error. A T1 error arises when a main crate controller occupied a CAMAC bus over 0.1

msec duration, and a T2 error arises when an ACC received a data with parity error or with irregular sequence, or could not receive three words within 1 msec. The serial driver waits an answer data from the up-link line for 10 msec duration. The received answer data are checked for parity and sequence and stacked to the received FIFO buffer. The sequence described above is repeated until the transmit FIFO buffer is empty. When the serial driver gets the specified number of answer data, it interrupts the device driver software to request a DMA transfer from the received FIFO buffer to the user program. The device driver returns the control to user program after post processing which begins at a completion of DMA transfer.

A CAMAC access request is done by calling QIO system routines from user program. Its scheduling is controlled by queue manager and execution of its request is performed by device driver. In this way, a CAMAC execution is done in multi-tasking environment. The required time for single CAMAC action is 1.9 msec and that for 170 multiple CAMAC actions is 27.0 msec. It is a sufficient speed to control the RF devices.

RF Device Control

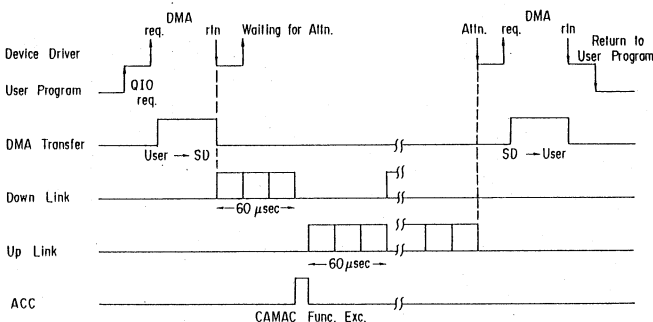There are two types of control for the RF devices;

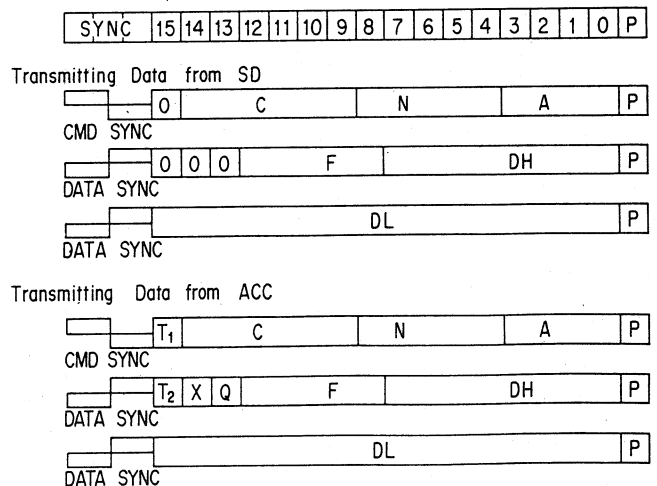Fig. 4 Time chart of CAMAC access sequence.

Fig. 5 Serial data formats.

one is an on/off control of the switches such as HV switch of klystron power supply and low-level RF switch, the other is a setting of reference voltage for feedback loops.[2] A switching control from CAMAC interface is done by a status output register (SOR) module which outputs a 12 Volt, 0.3 sec pulse. To avoid a hardware accident caused by on/off control from a computer, a klystron power supply is protected by a sequence controller and low-level modules have hard-logic of protection. For a voltage setting control, we use a reference voltage generator whose output voltage is controllable between 0 V and 10 V with 2.5 mV step or between -10 V and 10 V with 5 mV step. A pulse train generator (PTG) CAMAC module which outputs up-pulses or down-pulses with 512 pps speed is used for remote control of the reference voltage generator. A reference voltage to be set is transformed by the PTG into a pulse train, which controls the output voltage of the reference generator. Combination of the PTG and the reference voltage generator thus avoids a voltage jump to a set value.

Automatic Cavity Conditioning

APS cavities[3] have been processed up to a power level of 300 kW / 9 cells before they are installed in the main ring tunnel. They, however, sometimes need a conditioning before operation, especially when they are left idle for a long period or when they are exposed to an atmosphere for maintenance.

The conditioning program which is written in FORTRAN language runs with each RF unit (one klystron and four 9-cell cavities) as an independent task. They are controlled by another task using "shareable common" communication. A program monitoring RF device status such as voltage, RF power, vacuum pressure, and temperature is also used together with the conditioning control program. At the full running time, the number of conditioning task is 10 for Tsukuba and Oho node and 6 for Fuji node. In addition to these tasks the conditioning control program and the RF status monitor program can run if necessary. The conditioning program works according to a command and conditioning parameters which are passed by "shareable common". It reports its own working status using the same common. Since these communications do not interrupt any conditioning tasks, we can adjust its performance in real time.

During conditioning the program reads cavity vacuum, RF power and interlock status, and controls the RF power, as a cavity vacuum changes, according to the criteria shown in Table 1.

Table 1

Criterion of RF power control in conditioning

vacuum reading (torr)	RF power control
$P < 1\times10^{-7}$	increase with large step
$1\times10^{-7} < P < 2\times10^{-7}$	increase with small step
$2\times10^{-7} < P < 3\times10^{-7}$	power is kept constant
$3\times10^{-7} < P < 5\times10^{-7}$	decrease with small step
$5\times10^{-7} < P$	decrease with large step
$1\times10^{-6} < P$	switch off by hard wired vacuum interlock

The control of RF power is made by setting a reference voltage of the automatic cavity level control (ALC). Its minimum control step is 0.005 MV for one RF unit, so it corresponds to 0.02 kW step for 1 kW klystron output and 0.6 kW step for 1 MW. One cycle of the conditioning program consists of status reading and power setting takes typically 0.2 sec.

During conditioning frequent RF trips occur by a sudden pressure rise in the cavity and by RF reflection from the cavity caused by a discharge in it. When this happens the program sets the reference voltage to 98% of previous value and resets the RF switch after the fault has cleared. When the RF switch is turned on, the reference voltage of the ALC is ramping up to the setting value in 3 sec.

When the RF power has reached at a target power, the program enters a holding mode in which the RF power is kept constant until pressure of the vacuum decreases to an acceptable level. The target power of usual conditioning is 800 kW / klystron. The required time depends on the condition of cavity and is typically about 6 to 8 hours for good conditioned cavity. The first conditioning after installation in the ring usually takes more than 24 hours, because of a long idle period since processing.

Data Logging

In order to record an operating status of the RF devices, there are three logging programs running on each MicroVAX. They are as follows.

1. "INTL_LOG" : records worked interlocks
2. "FAST_LOG" : records selected status with short interval
3. "FULL_LOG" : records full status with long interval

The program "INTL_LOG" reads the RF switch status with 5 sec interval, and in the case of RF trip, writes down interlock names to the files and also writes down the bit-status of interlocks to "shareable common". These files are closed and printed out with moderate interval for a help of system diagnosis. The bit-status in the "shareable common" can be got in any time and displayed in a graphics how the interlocks are working.

The program "FAST_LOG" is a data logger which has a ring buffer of 600 records in the program and writes selected status into it with 25 sec interval typically. These records are used to diagnose a trouble of RF devices. The ring buffer is written to a file by a command from another logging control program. One can display and analyze it easily by an analysis program. The selected status is all on/off status and 30 analog values / 1 RF unit, such as klystron voltage, current, RF power, RF power reflection, vacuum, and temperature. The size of the written file is about 1.1 Mbyte, corresponding to 4.2 hours records at 25 sec interval.

The program "FULL_LOG" is also a data logger which records full status of RF devices into a file directly. The recording interval is typically 1 hour, and the file is closed once in a month usually. The full status consists of all on/off status and 130 analog values/1 RF unit, and the program records 10 RF unit data at one time. So, the size of one record is about 5.7 kbyte and the size of file amounts to 4.1 Mbyte at 1 hour interval. The recorded file can be also analyzed and displayed by the analysis program, and one can easily take the RF device status.

References

[1] S. Kurokawa et al., "KEK NODAL System" Proc. of the particle accelerator conference, Vancouver, 1985.
[2] E. Ezura et al., "The Low-level RF System for TRISTAN Main Ring" Proc. of the particle accelerator conference, Washington, D.C., 1987.
[3] T. Higo et al., "RF Cavity for TRISTAN Main Ring" Proc. of the particle accelerator conference, Washington, D.C., 1987.