27th EPS Conference on Contr. Fusion and Plasma Phys. Budapest, 12-16 June 2000 ECA Vol. **24B** *(2000) 1236 -1239*

Development of Data Acquisition System for Heliotron J

H.Okada, M.Takahashi[1)], Y.Ijiri, M.Shibano, K.Yaguchi, F.Sano and T.Obiki

Institute of Advanced Energy, Kyoto University, Gokasho, Uji 611-0011, Japan
1) Faculty of Engineering, Kyoto University, Sakyo, Kyoto 606-8501, Japan

1. Introduction

A new data acquisition system was built for Heliotron-J experiment [1-3], which was started in December of 1999. Heliotron J is a helical-axis heliotron device, therefore, a plasma has fully 3-dimensional structure. In toroidal direction, it is four linked-mirror configuration since the strong toroidal field is imposed at the four corner of the device. The amount of diagnostic data will be increased in order to understand 3-dimensional plasma properties.

Our previous data acquisition system had been operated successfully during Heliotron-E experiments, however, the replacement of the system was planned because of the limitation of the expandability and the difficulty of the maintenance since it was installed eight years ago. The main server which controls CAMAC system was VME-based SPARC machine (SunOS4.1) and its data was stored in IPI and narrow SCSI disks. More CPU power and disk speed are needed.

The recent progress of the commercial microcomputers and operation systems has changed the environment of developing data acquisition system. Many types of CPU, such as Pentium, Power PC, Alpha, SPARC, etc., and a lot of operation systems such as Microsoft Windows, Mac OS, UNIX (-like) OSs are available. We can make selection among many combinations of them. Requirements for the function of our system are 1) fast and stable system, 2) easily expandable and upgradable system, 3) succession of previous software and hardware, 4) easy maintenance.

The programs of the previous system were written in C language under SunOS.4.1. UNIX OS has advantage in network connectivity. It is very convenient for out system. We selected NetBSD as the server OS since we are familiar with BSD UNIX and NetBSD is available for multi-platforms. Besides, it is found to be very stable from our experience. For clients OS, Linux is used since there are many applications. The CAMAC related software works only in the CAMAC server, however, data viewers and other several programs must work in Linux clients and previous SunOS machines. In this point of view, software portability is very important. Therefore, only Xlib is used in the whole system software for the GUI component.

2. System Hardware

Our system consists of CAMAC ADCs and scalers, a relay signal processor, a delay trigger timing processor, a CAMAC server, a data file server, a discharge parameter display system, a heliotron power supply monitor, calculation servers and client computers (Fig.1). The relay signal processor collects signals (shot number, coil currents, measurement positions and so on) from the power supply controller and diagnostic devices of Heliotron J and transfers the setting data to the CAMAC server via RS232C. The trigger timing processor generates up to 30 delay triggers for diagnostics and sends their settings to the CAMAC server via RS232C.

The previous CAMAC server was a SPARC system equipped with the VME-based parallel bus interface, Kinetic 2917, which is connected to a crate controller Kinetic 3922. The components in the CAMAC crate are used in the new system. PCI bus is the most popular interface bus in the microcomputers and faster than VME bus. PCI bus interface for the 3922 is Kinetic 2915, which can control up to 8 CAMAC crates. Most process in getting data from the CAMAC system is integer process. For this purpose, AT crone computer has good cost-performance and many peripherals for that architecture are available. We selected a Pentium-based AT crone computer with redundant power supply (400W x 2) connected to UPS as a CAMAC server.

All microcomputers are connected with 100BaseTX ethernet cables and switching hubs. Digitizers have 500 channels and the number of the relay signals is 1500. Obtained data is stored in hard disk drives (0.1 TB, LVD disks) and magneto-optical (MO) disks (4GB per disk) of the file server, simultaneously. The shot number and coil current settings are displayed by LCD displays in the control and data processing rooms. Heliotron power supply monitor is installed as an independent data acquisition system, which collects signals of the coil power supply and plasma monitor signals for the machine operation and system maintenance.

3. System Software

System software consists of 9 programs, which define CAMAC parameters, monitor system time, control CAMAC and graphic output, take data from a relay signal processor and a delay trigger processor, store data to MO. Main menu controls all online processes including a discharge parameter display system and displaying and printing of signals. Each program is invoked by the parent process and communicates to other processes by signaling method.

CAMAC control program and data viewers are also developed. The CAMAC control program is GUI based one, which consists of three modules, 'crate', 'module' and 'function'. 'Crate' defines the CAMAC module name and its station number in a crate. A sampling time, numbers of channels and data words, voltage range and so on are set by 'module'. In

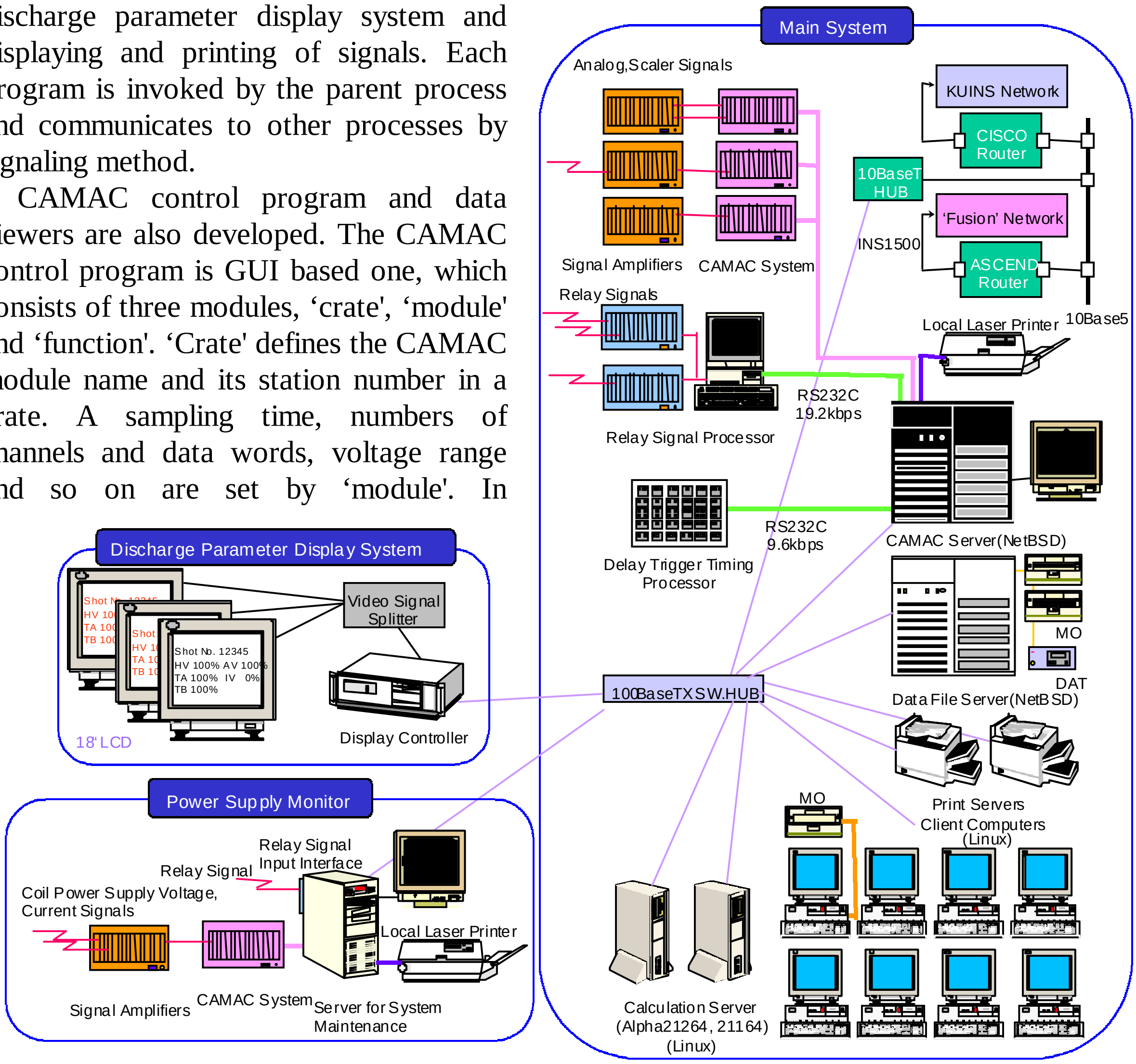

Fig.1. A schematic view of data acquisition system for Heliotron J.

‘function', CAMAC functions for pre- and post-trigger operations are described.

A device driver for CAMAC crate controller interface (Kinetic 2915) is ported from that of Linux and added several new features. The limitation of the amount of data in DMA block transfer is removed and IO block transfer function is incorporated. The data transfer rates by DMA and IO method are almost the same. The transfer rate from CAMAC ADC (Kinetic 4008/4054) to the server memory is about 560 kbytes/s with Intel's 400 MHz Pentium II processor. This CPU speed is considered to be sufficiently fast for data transfer since the transfer rate was not changed with slower 300 MHz Pentium II.

The Obtained data from the CAMAC system are stored in the data file server. Each signal is stored separately. Data full name is /data_top_directory/date/shot_number/signal_name. The stored data consists of a header part and a data part. The header part contains shot number, date and time of the shot, the information of the coil currents, used CAMAC module name, ADC resolution, the maximum and minimum voltage of ADC, the delay trigger timing, the number of data words, and the signal specific remark and so on. The shot number and its date are tabulated in a file (shot-date table). All applications refer to this table first to get the directory name of the specific shot.

Data sharing is made by NFS. Data region in the data file server is read only file system for users and users utilized data in NFS mounted clients, can not enter the data file server directly. User files are located in the user file server. The home directories of users are also shared by NFS. Users who use data in computers outside of Data LAN must enter some computer inside Data LAN. We make some limitation of entering Data LAN for security reason.

4. Sequence Flow

A discharge pulse of Heliotron J occurs at every 4 to 10 min. The main trigger is generated at 10 seconds before the shot pulse. The data acquisition system invoked gets this trigger signal from the I/O CAMAC module, then, starts sub-program modules such as the serial data transfer programs from a trigger signal processor and a relay signal processor at the main trigger timing. All CAMAC modules are reset and start digitizing at this timing. Discharge parameter displays inform the timing of ten seconds before a discharge by changing its background color. The power supply monitor also begins CAMAC digitizing. This system ordinarily takes data for 3 seconds, which corresponds to the duration time of the coil current. However, the flat top of coil current is about 0.5 sec, therefore, most of diagnostic data obtained in the main system have shorter period than that of the system of maintenance.

After each discharge, the sequence program waits for the assertion of Q flag from CAMAC modules. When Q flag of some module is asserted, the data transfer begins. It is repeated until all transfers are finished or timeout event occurs. All data are transferred to data file server after each data is given its signal name and header. MO-write process follows after that. ‘Shot note’ (memorandum for the discharge conditions) is also stored in the same directory as the signal data. Shot-date table is updated after writing procedure, then, user can read out experimental data or can use data viewers for the latest shot.

5. Data Viewers

Three data viewers are prepared for the convenience of the researchers in order to use mainly during experiment. The plot patters are, time evolution, shot by shot variation, X-Y plot. Example of a time evolution is shown in Fig.2. Up to 75 signals can be displayed in a window. Shot number and coil currents are located in the upper box. Number of signal frames can be chosen in the range from 2 to 18. Multiple signals can be written in a frame. Waveforms can be shifted, zoomed by pushing buttons in the bottom line. A cursor can be used for displaying the figure of the signal at indicated timing.

For all patterns, parameter editors are prepared as well. The editor for the time evolution plot is shown in Fig.3. 64 pages can be stored and 75 signals are defined in each page. We can choose a frame number, a signal timing, data conversion and offset procedure, color, line style, and so on. Signals of multiple shots can be displayed in a window by the selection of ‘Shot mode’ and ‘Superpose’. Output device is selectable among display and printers. Libraries for obtaining data in FORTAN and C are also prepared for the analysis.

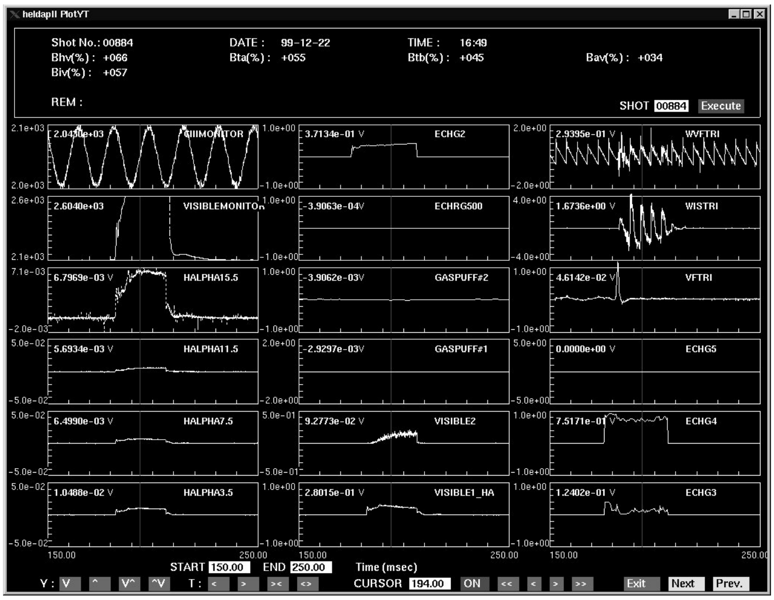

Fig.2. Time evolution display.

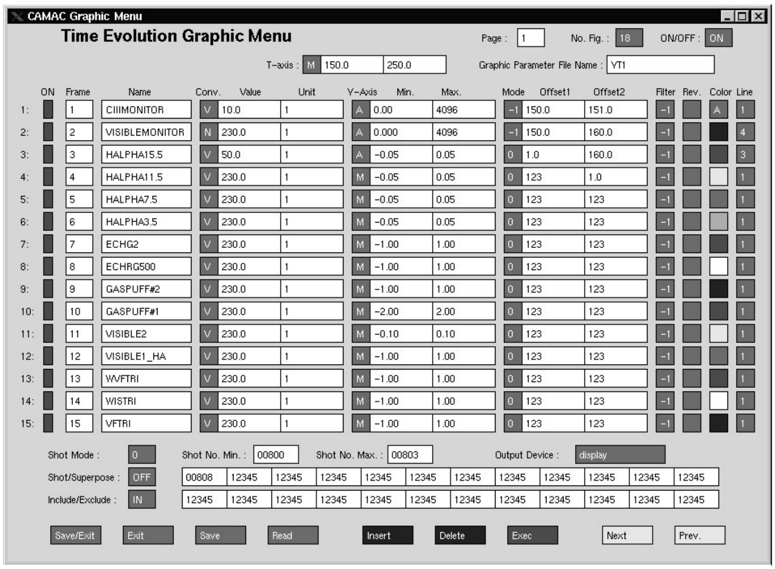

Fig.3. Parameter editor for time evolution plot.

6. Summary

A new data acquisition system for Heliotron J was completed. Several viewers and their parameter editors make it easy to check and review diagnostic devices during experiment. This system consists of common parts mainly, therefore, the cheap and efficient maintenance can be attainable only by stocking several important parts. This system is easily expandable by adding CAMAC servers and data file servers independently in the future. All source code concerning with this system is available for the maintenance.

References

[1] F.Sano, et al., J. Plasma Fusion Res. SERIES, Vol.1 (1998) 168.
[2] F.Sano, et al., Proc. 12th International Stellarator Workshop (Wisconsin, USA, 1999).
[3] T.Obiki, et al., Proc. 12th International Stellarator Workshop (Wisconsin, USA, 1999).