§9. Design for Real-Time Streaming Digitizer System

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The future plan for the newest fusion devices using the superconducting magnets, such as LHD and Wenderstein 7-X, is to hold the quasi steady-state plasma for more than ten minutes. For the LHD project a long-pulse plasma experiment of one-hour duration is planned. In this quasi steady-state operation, the data acquisition system will be required to continuously transfer the diagnostic data from the digitizer front-end and display them in real-time.

In these circumstances, the data acquisition system also has to run in real-time so that it can display the transient behavior in accordance with the plasma discharge in progress. Thus the acquisition of streamed data will be required quite soon. The recent growth in information technology has enabled the non-stop generation, transfer and restore of high-bandwidth data within a definite delay. It is known as data streaming technology.

Conventional data acquisition systems are usually called the batch-processing ones, and they have often applied the CAMAC digitizers in short-pulse plasma experiments.[1] In long-pulse experiments, however, such a post-processing mechanism will be ineffective because any diagnostic data cannot be seen throughout the duration.

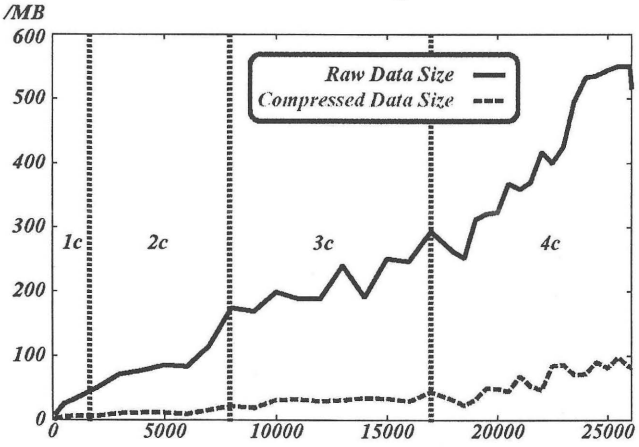

Fig.1. Growth of shot-by-shot data size acquired by LABCOM system: The rawdata size keeps growing almost as double as in the previous cycle.

Design Requirements

In general, the MHD fluctuation diagnostics will request faster A/D conversion rate like 500 kHz sampling toward the new digitizer system.[2] Nowadays, for the 2- or 3-dimensional spatial distribution measurements, average diagnostics often have over 100 digitizer channels. It means that each DFE will produce a continuous 100 MB/s data stream. The basic specification for one DFE chassis can be summarized as follows.

(1) Data transfer rate should be above 100 MB/s in non-stop continuous operation.
(2) One should contain about 100 digitizer channels.
(3) Linkage between the DFE and the host computer should be electrically isolated and the distance (about 500 m) extendable by using the optical fibers.
(4) High connectivity with the PC/EWS host computer is required.

Among present PC and EWS technologies, the PCI bus is conceived to be the most substantial standard bus that can satisfy the 100 MB/s bandwidth requirement. As the PCI bus has been designed just for the PC extension slot, it has no wide front panel to implement multiple coaxial connectors for analogue signal inputs, and neither does it have the capability of electrical insulation from PC main body that contains many noise sources. It also has a logical limitation of the maximum 8 slots or devices in one PCI bus. The CompactPCI standard designed for the modular front-end would resolve such restrictions, with keeping the PCI compatibility.

Data Transferring Interface

For the optimal link media between the peripheral DFE and the host computer, we examined possible candidates like SCSI, USB, IEEE1394, FibreChannel or PCI-PCI bridge. Another essential condition is the distant expansion and the electric isolation by using optical fibers. Taking account of the easiness to obtain commercial products, only the SCSI optical transceivers or the FibreChannel are available at the present time. The SCSI interface, however, was not originally designed for distant transfer, and the extension becomes more difficult at higher rates of Ultra2Wide (80 MB/s) or Ultra160 (160 MB/s). We finally discovered that the FibreChannel standard has the unique possibility of providing the capability of 100 MB/s data transfer. Even it will be insufficient for our maximum stream of non-stop 100 MB/s, when considering the system overheads.

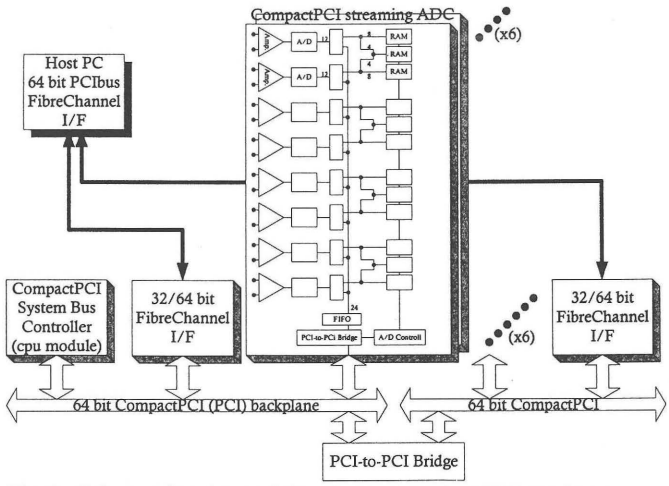

Fig.1. Schematic view of the CompactPCI DFE system:

References
1) Nakanishi, H. et al.: NIFS-TECH-9 (2000).
2) Nakanishi, H. et al.: NIFS-TECH-10 (2001).