DATA ACQUISITION SYSTEM BASED ON PCS FOR THE LHD THOMSON SCATTERING DIAGNOSTIC

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Abstract

In the LHD Thomson scattering diagnostics, more than 1000 channels data must be AD-converted in 20 μsec and transferred at the speed of 5 MB/sec. In order to satisfy the requirements, a high-speed data acquisition system based on FASTBUS and PCs was developed. It consists of sixteen FASTBUS ADC modules (1881M ADC 64-channel inputs, 13 bit, LeCroy), a FASTBUS segment manager (1821 SM/I, LeCroy), a fast data logger and two PCs. A PC controls the 1821 segment manager, which in turn controls sixteen 1881 ADC modules. Data are transferred through the data logger, and saved on HDD in the PC. In the case data transfer speed from FASTBUS exceeded HDD write-time, the data are stored temporarily on 4 GB RAM in the data logger. Thus, the data acquisition system can input more than 1000 signals, AD-convert all data in 12 μsec and keep up with 20 MB/sec data transfer.

1 INTRODUCTION

Thomson scattering diagnostic is the most reliable and therefore widely used method to measure electron temperature and density in fusion-oriented plasma experiments. In the Thomson scattering diagnostic installed on the Large Helical Device (LHD), laser beams delivered from up to five Nd:YAG lasers (10 ns pulse width, 0.6 J, 50 Hz repetitions) are injected into plasma in sequence. And in order to get high resolutions, 200 spatial points are measured. Then, scattered light is collected and focused onto an array of 200 optical fibers by a large collection mirror. The scattered light is transferred to the diagnostic room through 200 optical fibers and divided into five spectra with polychromators there. The spectral-resolved light is converted into electric signals by avalanche photodiodes. Then, data became 1000 signals. (Ref. Figure 1) And it is also necessary to input some monitor signals that include laser power, laser beam positions and timing of the laser shot. So, more than 1000 signals must be inputted to the data acquisition system

Each scattered light accompanies fluctuating plasma light, which introduces errors in the deduced electron temperature and density and then are to be treated statistically. For this purpose, plasma light is measured at 8 instances every 20 μsec after each laser injection. The time sequence of this operation mode (standard mode) is depicted in Figure 2 (a). The frequency of the lasers is 50Hz and the amount of data in one instance is about 1000 words. So, data must be transferred at speed of about 5 MB/sec.

Occasionally, we are interested in the time evolutions of electron temperature and density that are too rapid to be measured by the standard mode. For such a case, the burst mode whose time sequence is shown in Figure 2 (b) is employed. In this mode, lasers are injected at very shot interval (100 μsec). Then minimum interval of data acquisition becomes 20 μsec in the burst mode. So, ADC speed must be faster than 20 μsec.

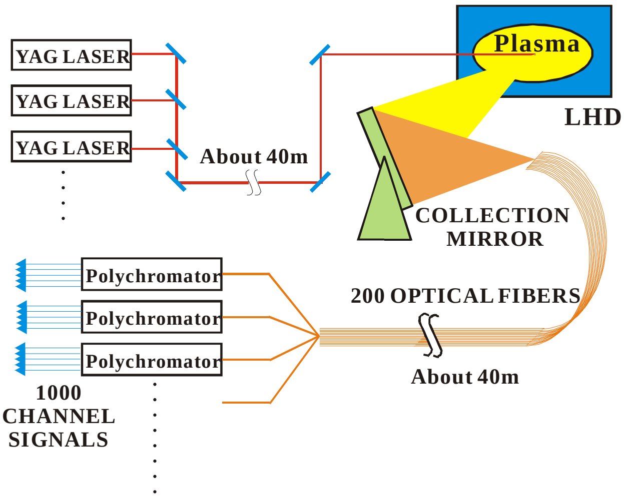

Figure 1: The LHD Thomson scattering diagnostic.

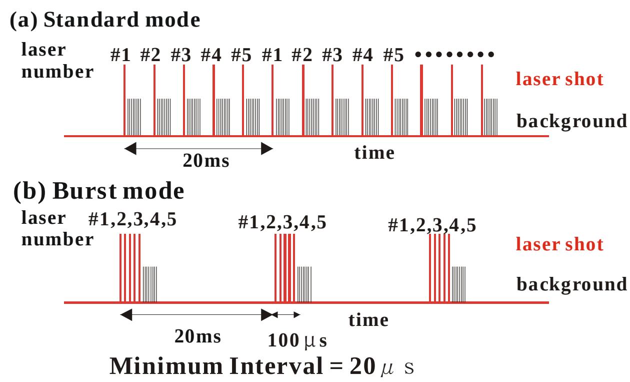

Figure 2: The standard mode and the burst mode.

2 ADOPTION OF FASTBUS

After examining several commercial available data acquisition systems (CAMAC, VME) that meet the above requirements, we reached a decision to use FASTUBS. The transfer speed of FASTBUS is 10 MHz for 32-bit data. And a FASTBUS charge ADC module (1881M ADC) has 64 channels per a module. Then, sixteen 1881M modules can deal with more than 1000 channels signals. It can AD-convert all channels data in 12 μsec in

13-bit mode (9 μsec in 12-bit). It also contains multiple events buffer, which can store up to 64 events. Therefore, it can store data temporarily in the burst mode.

And 1821 SM/I (Segment Manager Interface), which can transfer data at full FASTBUS speed (20MB/sec), is adopted for a FASTBUS controller.

So, the system can input more than 1000 signals, AD-convert all data in 12 μsec and transfer data with the speed up to 20 MB/sec. It satisfies the requirements for LHD Thomson scattering diagnostic. The FASTBUS modules in use are listed in Table 1.

Table 1: Composition of FASTBUS

Module	**Maker**	
1821SM/I ×1	LeCroy	Controller
1821 ECL ×1	LeCroy	ECL changer
1881M ADC ×16	LeCroy	ADC
1691B ×1	LeCroy	PC Interface

3 CONTROL OF FASTBUS

We adopted a PC to control the FASTBUS segment manager, because a commercially available interface card (1691B, LeCroy) makes it possible to control the system without any other developments. The PC makes the set up of all modules and controls the start and stop of the segments manager, which in turn controls the 16 ADCs.

And a control program is easily made with the use of LIFT (LeCroy Interactive FASTBUS Software Toolkit), which provides FASTBUS control functions for "C" language. LIFT makes it possible to make C program easily without any professional knowledge for FASTBUS. Most of the program was made with LIFT. But some functions of LIFT do not have good processing speed. So, some parts of the program that need very fast processing speed are made with SONIC (Sequencer On Line Interactive Code), which is macro assembler for 1821 SM/I. Though it was not so user-friendly like LIFT, it can set detail configuration that cannot be set by LIFT and very fast.

In this way, we were able to make a control program using "Quick C" with low cost and in short period (several months).

4 DATA TRANSFER FROM FASTBUS TO A PC

AD-converted data are transferred from FASTBUS to a PC. But, there are not any commercially available PC interfaces that can read a large amount of data from FASTBUS at high-speed. The PC interface 1691B cannot transfer a large amount of data at high-speed. Though we considered developing a new device to transfer data to a PC directly 5 years ago, it was difficult and very costly. Then, the system that transfers data from FASTBUS to a PC through VME was constructed based on LeCroy Application Note-46 [1]. (Ref. Figure 3).

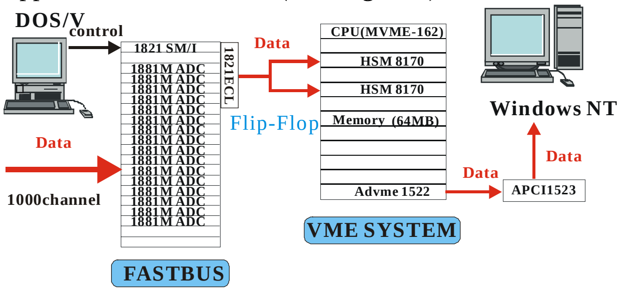

Figure 3: Data transfer through VME

A triple-port memory HSM8170 is used to read data form FASTBUS. Because the memory can have only 1 MB data at the maximum, data are transferred to a 64 MB large-capacity memory (CI-VME40) on the same VME. But the triple-port memory cannot read data from FASTBUS during the data transfer to the large-capacity memory. Therefore, two HSM8170 are used in flip-flop. While one HSM8170 transfers data, the other acquires data, and vice verse. In this manner, large data are transferred without interruption.

The data stored in the large-capacity memory is transferred to the PC with the use of shared memory (advme1522, APCI1523) afterward.

The modules used in the VME system are listed in Table 2.

Table 2: Composition of VME system

Module	**Maker**	
MVME-162 ×1	MOTOROLA	CPU
HSM 8170 ×2	CREATIVE ELECTRONIC SYSTEMS	Triple port memory
CI-VME40 ×1	Chrislin Industries	64 MB memory
Advme 1522 ×1	Advant	Shared memory
APCI1523 ×1	Advant	Shared memory

This system had been used for several years. But in this several years, cost of memory decreased largely and image data processing technique developed rapidly. Several years ago, it was very special and difficult technique to transfer a large amount of data to a PC. But recently, this type of technique became very popular. So, we newly developed a data logger with the use of the technology. The cost of making a new data logger is much lower than that of making a backup VME system. And it was relatively easy because a device program is commercially available.

Data are transferred to a PC (Windows NT) through the data logger, and saved on HDD in the PC as shown in Figure 4. The data logger has 4 GB RAM. When data transfer speed exceeded HDD write-time, the data are stored temporarily on the RAM. Then, the data logger can keep up with 20 MB/sec data transfer.

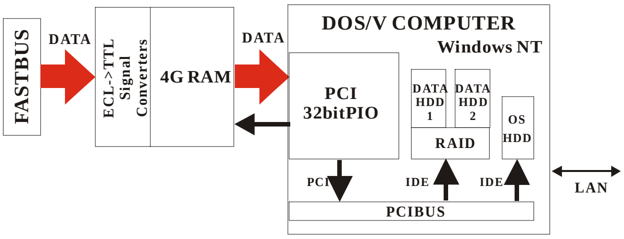

Figure 4: The data logger.

The system using VME also satisfied the requirements. But performance was improved in some points. Though the old system could keep up with 10 MB/sec data transfer, the new system can keep up with 20 MB/sec. Since the speed from the data logger to the PC depends on environments and conditions, we cannot say accurate speed. But the speed improved more than twice. The speed from VME to PC was 2 or 3 MB/sec. The speed in new system is approximately more than 6 MB/sec. In addition, it is most important, the system became very stable. Though the old system was occasionally stopped, the new system had not stopped at all due to itself problem last LHD experiment.

5 CONCLUSIONS

We have constructed the high-performance data acquisition system based on FASTBUS and PCs. It can input more than 1000 channels data, AD-convert all data in 12 μsec and transfer data to the PC with the speed up to 20 MB/sec. It was constructed at low cost because of the use of PCs and PC technology. And maintenance and improvements of system are easy thanks to the use of PCs.

And the AD-converted data are stored in the PC. Then, another PC easily accesses the data. The data are shared on the network and analysed with another PC (Windows 2000) and then registered to the LHD database immediately

6 REFERENCES

[1] LeCroy Application Note-46, PASSING DATA TO VME VIA ECLine

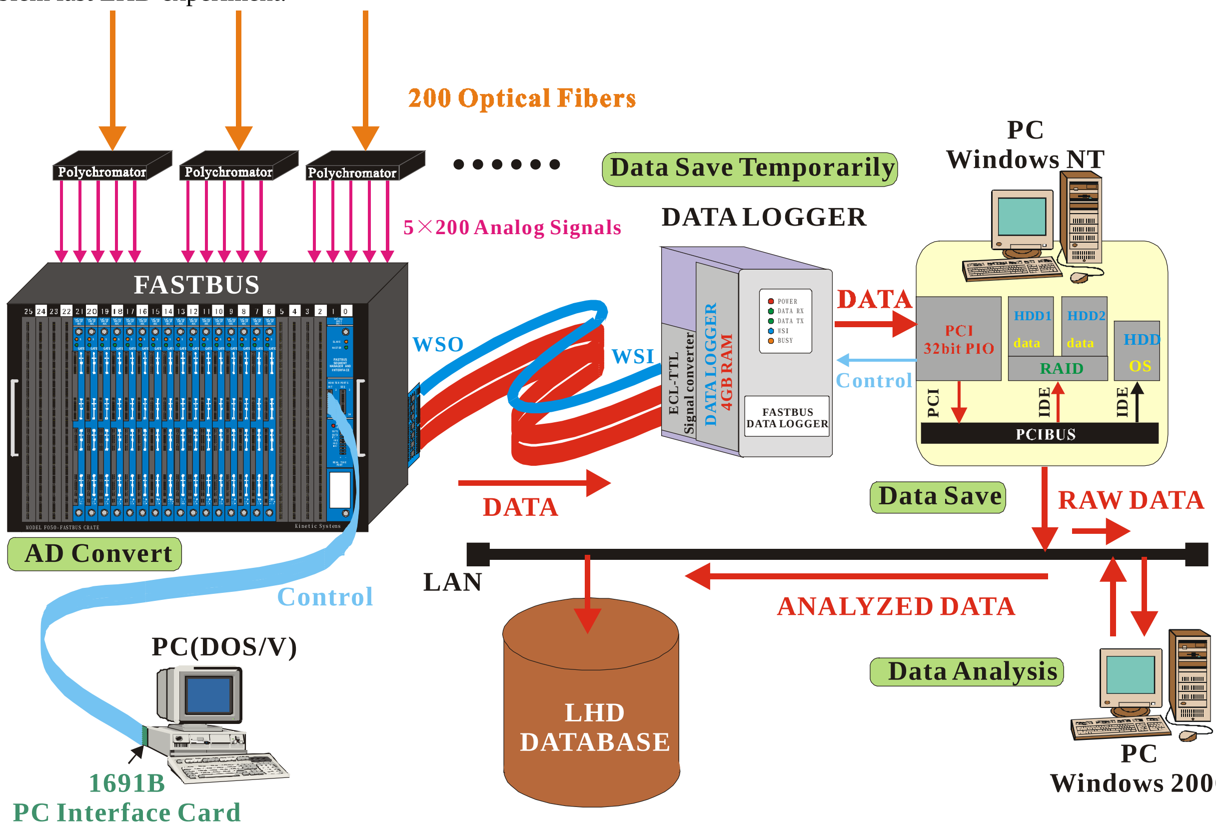

Figure 5: The LHD Thomson scattering data acquisition system