10. OTHER ACTIVITIES ON CONTROL AND DATA ACQUISITION AND PROCESSING

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10.1. INTRODUCTION

This Project had four main research lines in 2003, concerning the development of:

- Galvanic isolated PCI transient recorder module;
- Event-driven reconfigurable real-time processing system for the next generation fusion experiments;
- Low-cost, fully integrated, event-driven real-time control and data acquisition system for fusion experiments;
- Water-cooled, high compaction ratio Linux cluster.

10.2. GALVANIC ISOLATED PCI TRANSIENT RECORDER MODULE

10.2.1. Main activities

The following main activities were performed in 2003:

- Definition of the module architecture accordingly to JET requirements;
- Design of the schematic, printed circuit board, programmable logic and control DSP firmware of the module;
- Assembling and testing of a prototype;
- Successfull demonstration in August at JET of the operation of this module.

10.2.2. Module description

Control and data acquisition systems for plasma diagnostics are continuously required to keep up with the ever-growing demands of Fusion experiments. These requirements include, among others, multi-channel data readout, real-time signal processing, a wide range of timing/triggering solutions and data cleanness.

The developed module, aims at incorporating these advantages in a multi-channel transient recording architecture that comprises eight galvanic isolated (1 kV) analogue inputs capable of acquiring simultaneously on all channels at a rate up to 2 MHz, and has a local memory capacity of 256 MSamples, at a 14-bit resolution. The module architecture relies on state-of-the-art hardware components, namely latest generation DSP and FPGA devices, so as to implement these and other functionalities. Control software packages have been developed to obtain a fully functional unit. Figure 10.1 presents the transient recorder module hardware.

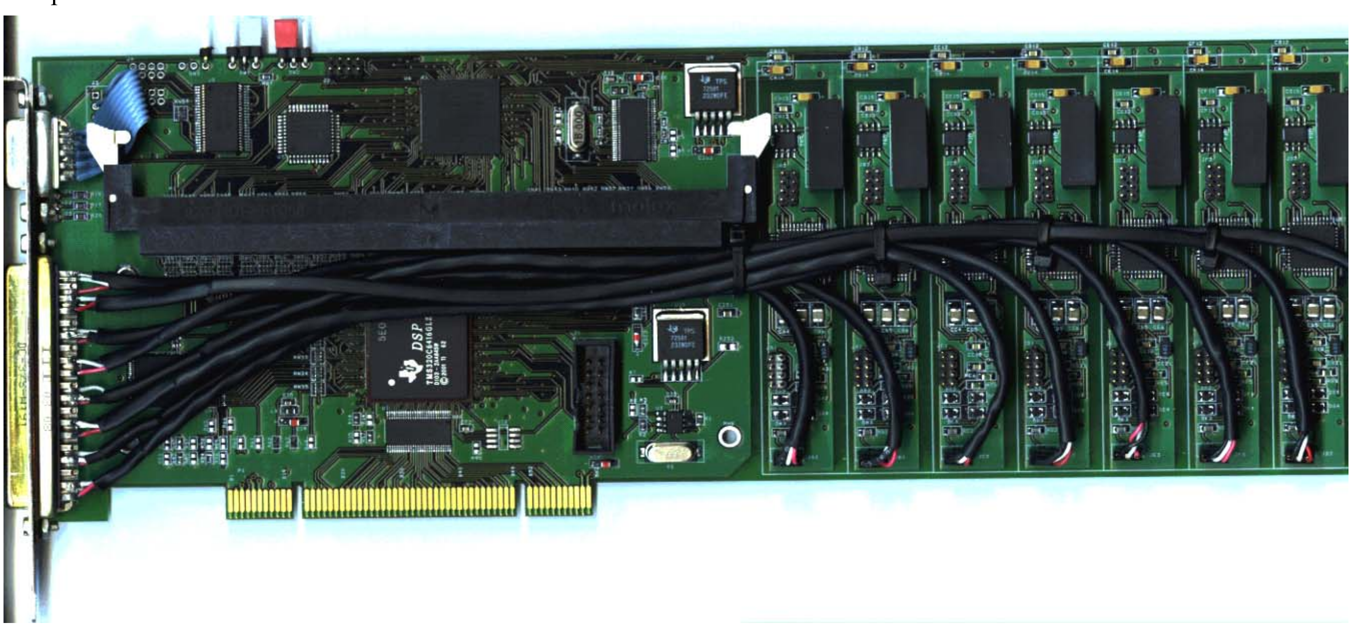

Figure 10.1 - Eight channels galvanic isolated transient recorder module

10.3. EVENT-DRIVEN RECONFIGURABLE REAL-TIME PROCESSING SYSTEM FOR THE NEXT GENERATION FUSION EXPERIMENTS

The following main activities were carried out in 2003:

- Identification of the adequate software and hardware platforms;
- Development of a preliminary multiple FPGA/DSP based hardware design;
- Definition of the software design workflow.

10.4. LOW-COST, FULLY INTEGRATED, EVENT-DRIVEN REAL-TIME CONTROL AND DATA ACQUISITION SYSTEM FOR FUSION EXPERIMENTS

The following main activities were made in 2003:

- Identification of a System-On-Chip architecture suitable for the development of low-cost, modular, long operation period and network interconnected data acquisition and control instruments;
- Finalization of the preliminary design of the data acquisition and control module with a high number of channels;
- Initial cost and performance estimation, which indicates that this module can be produced at very low cost per channel and can speed the data acquisition subsystem commissioning task.

10.5. WATER COOLED LINUX CLUSTER

10.5.1. Main activities

The following main activities were performed in 2003:

- Conceptual design, commissioning and testing of the system;
- Development of the operation software.

10.5.2. Description of the system

Orionte is a Pentium 4 linux based cluster intended for heavy numerical calculus at Centro de Fusão Nuclear (Figure 10.2). With a high volume compaction ratio and a low cost design, 24 Gflop per 8 CPU has been achieved. This is done by water cooling the 2.4 Ghz CPUs so that 8 boards/1 GRam can be housed in a regular 21", 6U rack system. The cluster has a 1Gbit ethernet dedicated switch. The master node provides NFS services and booting configuration to the other diskless nodes. Having tried common Linux distributions, such as, SUSE, and Fedora CORE 1, the Linux Gentoo distribution proved to be the most stable, robust and flexible regarding performance and reconfigurability. On this system, several clustering technologies can be used such as OpenMosix, LAM/MPI, MPICH and OpenPBS batch system for job management and execution.

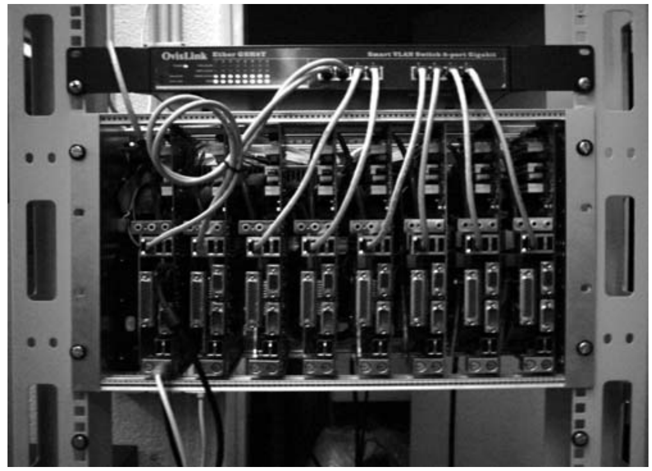

Figure 10.2 - Front view of the Orionte cluster.

10.5.3. Results of the tests

This cluster has been tested using a code for the determination of the plasma current profile, using a 100 filament current gride approach. The code is written in Matlab and uses a parallelization consisting of time slicing the probe signals and spreading them between the available nodes. The signals are acquired at 12.5 kSample/s and the fitting calculations provide a current profile of an ISTTOK's poloidal section every 400 ℜs on a grid of 100 current filaments.

The average fitting errors, calculated with relation to the probes signal magnitudes, were 8.65 % for pulse 10767 and 14.1 % for pulse 10774.

This method was benchmarked for a typical flat top ISTTOK discharge, shot 10767. Previously, the non-parallel version of this code took more than 15 hours to complete in a common Linux desktop PC based on a Pentium 1.7 GHz architecture, where the code was developed. The parallel implementation done with MPI over Matlab decreased the execution time from 7 hours using only one node to 1 hour using the current 8 nodes of the Orionte cluster. More precise benchmarks allowed us to estimate an efficiency of approximately 90% for a small cluster from 8 to 48 nodes. This efficiency is calculated by the ratio between the total execution time for a single node multiplied by the number of processors used over the total execution time for the parallel version. Based on this, one can estimate that for the forthcoming 48 node Orionte II cluster, the processing time will be further reduced to below 10 minutes for a single shot. This will also be improved with optimized versions of the code currently under development.

The following reduced view (Figure 10.3) is taken from the movie of a characteristic ISTTOK shot and shows the plasma current position movements along the discharge.

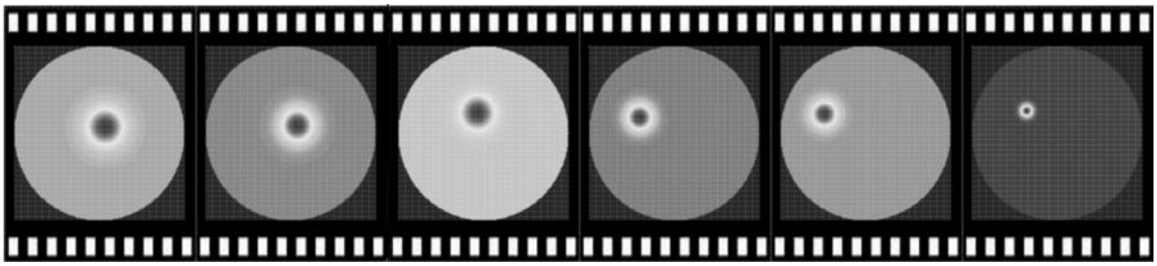

Figure 10.3 – Frames taken from a plasma current position movie, were only six of 80 are presented.

The real movie has a frame rate of 2.5 kHz, being played in "slow motion" at a rate 166 times slower, allowing a better understanding of what is going on in the discharge.