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A distributed real-time system for event-driven control and dynamic data acquisition on a fusion plasma experiment

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Abstract

A distributed real-time trigger and timing system, designed in a tree-type topology and implemented in VME and CAMAC versions, has been developed for a magnetic confinement fusion experiment. It provides sub-microsecond time latencies for the transport of small data objects allowing event-driven discharge control with failure counteraction, dynamic pre-trigger sampling and event recording as well as accurate simultaneous triggers and synchronism on all nodes with acceptable optimality and predictability of timeliness. This paper describes the technical characteristics of the hardware components (central unit composed by one or more reflector crates, event and synchronism reflector cards, event and pulse node module, fan-out and fan-in modules) as well as software for both tests and integration on a global data acquisition system. The results of laboratory operation for several configurations and the overall performance of the system are presented and analysed.

Keywords: Distributed real-time system; Dynamic data acquisition; Fusion plasma

1. Introduction

The new generation of magnetic confinement fusion experiments aims at long-pulse or even steady state operation [1–4]. Control and data acquisition will be merged in a distributed real-time system permitting the implementation of dynamic experiment scheduling, event-driven discharge control with failure counteraction and dynamic data acquisition [5,6].

Such control and data acquisition system consists on multiple nodes sharing plasma state variables, that are propagated through the interconnections of a low time latency network, which provides support for management and transmission of prioritised signals, alarms, events and other objects as well as trigger scheduling and synchronism distribution.

Actual network links are oriented for bulk transfer of data having time latencies of no less

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than tens of ms and provide no-deterministic propagation of triggers and synchronism. These restrictions limit real-time operation since results may not be attained with acceptable optimality and predictability of timeliness. Even multimedia-oriented links, with its reserved bandwidth for time-critical tasks, cannot fully satisfy the required performance.

A distributed trigger and timing system (TTS) has been developed in order to fill this gap by providing sub-microsecond time latencies for the transport of small objects as well as providing accurate simultaneous triggers and synchronism on all nodes in a large experiment campus where previous timing systems architectures are unsuitable.

The architecture and hardware components of this system are described elsewhere [7,8].

This paper is organised as follows: Section 2 includes a short description of the system; Section 3 presents the technical characteristics of the VME hardware components; Section 4 contains the test results; in Section 5 the software implementation is described and in Section 6 the conclusions are presented.

2. System description

The Trigger and Timing system has been designed in a tree-type topology, with a central unit providing time synchronisation and event distribution between all satellite nodes (Fig. 1). The interconnections allow bi-directional communication from one to all other nodes permitting them to synchronously share small data objects.

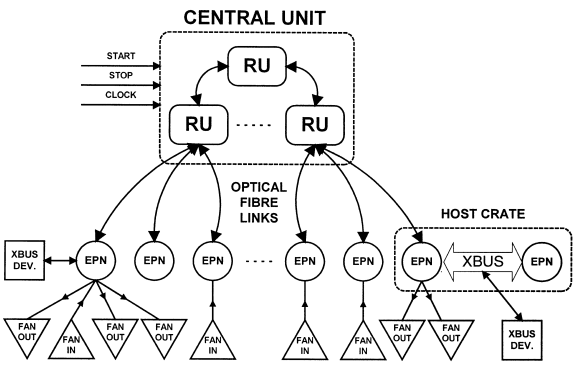

Fig. 1. The topology of the trigger and timing system.

The central unit contains at least one reflector unit (RU) holding a maximum of 16 event and synchronism reflector modules (ESR). An optical fibre cable connects each ESR to an event and pulse node (EPN) module. Expanding the number of connections up to 256 can be accomplished by using a maximum of 17 RU. Pre-defined and event dependent timing actions are performed in each of the EPN inserted in host crates scattered all over the experiment campus. Expansion of the input/output capabilities of the EPN is carried out by fan-in and fan-out modules and through the external event bus (XBUS) which allows to connect a mix of EPN and special function cards in the same crate.

3. Technical characteristics of the VME hardware components

3.1. Event and pulse node module

Each EPN produces the timing signals required for the operation of the experiment diagnostics and digitisers. It also performs the broadcasting, processing and recording of the occurrence of externally generated events for real-time control purposes.

The EPN module contains an eight output channels timing unit (TU) [8], implemented in a field programmable gate array (FPGA) which is programmable through the host bus with a vector of timing parameters, defining several sequences of pulses per output channel, which can vary dynamically with time and/or with events, such as multiple frequency clock pulse trains for data acquisition, signals generated at predefined times to synchronise the diagnostic operation and sequences of gating signals of variable duration required for control functions. The TU includes a time counter that starts counting after receiving a START event allowing to record the time of occurrence of the events and to start the static sequences at predefined instants.

The EPN also routes the events bi-directionally to the optical communication interface, the host bus, the XBUS and one-way from the eight local inputs and to the TU (Fig. 2).