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FASTBUS IN EUROPE, STATUS AND PLANS

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Abstract

Fastbus activity in Europe has definitely taken the direction of implementation and application. At SIN a system has successfully been commissioned and at CERN a multicrate configuration is being prepared for 1984. The importance of a single common data acquisition standard having been recognized for LEP experiments the data acquisition systems in preparation for these gigantic collaborations are largely to be based on Fastbus. Starter kits have been composed for the various collaborating groups and laboratories while the first commercially produced modules have become available.

The ESONE-ASSG has continued its coordinating role and, having published a European version of the Fastbus specification, is now actively engaged in compiling supplementary information in documentary form for engineers, programmers and users.

Introduction

During the past year a strong increase has taken place in Europe in the plans for the application of Fastbus. In particular the collaborations of European laboratories and universities which are preparing the four experiments to be installed at the Large Electron Positron collider (LEP), are in the process of laying out data acquisition systems, based for the greater part on Fastbus.

However, before these gigantic experiments will become operational experience will have been gained with smaller systems in other experiments.

At the Swiss Institute for Nuclear Research (SIN), a Fastbus system has been successfully taking data since August.

At CERN the Fastbus pilot system¹⁾ has been expanded and continues to give excellent performance. For another experiment, NA-31²⁾, Fastbus has been adopted because of its advantages over CAMAC or any other standard. The system in this experiment will become operational in 1984.

In order to facilitate the entry into Fastbus design and to allow evaluation of the various aspects of its specification, starter kits have been composed and are being delivered to the various LEP collaborations and other interested groups.

The ESONE committee has endorsed the Fastbus specifications. A first provisional European version has been issued and a final version as a European document is in preparation. The ESONE Advanced System Study Group (ASSG) has met once this year and is orientating future meetings towards applications and software.

Some Fastbus hardware has become available from European industry, and many companies have shown interest in producing crates, power supplies and modules.

In the following paragraphs a short overview is given on the major activities and plans.

Fastbus systems in operation

The first Fastbus system which became operational in Europe is the very fast trigger processor in the experiment done by the European Muon Collaboration at CERN. This pilot system¹⁾ has been extremely useful to familiarize with Fastbus, and to check and complement the specifications. After a long and successful period of running during last year the system has been expanded by adding new modules and it has again been in operation since last summer.

In August, at SIN in Villigen, Switzerland, a three crate Fastbus system with sixty modules of six different types successfully started to take data as part of the SINDRUM experiment. Input signals come from multiwire chambers and scintillation counters. The system performs event filtering based on charge and track selection. Some of the modules in this set-up have been designed and produced by industry.³⁾

Fastbus systems in preparation

An interesting application of Fastbus is being prepared for the experiment NA-31 at CERN. This is an experiment to investigate K^0 decays. Its detector is composed of two large planar drift chambers, a liquid argon calorimeter, a hadron calorimeter and some other elements. The first level (real time) trigger rate is $\approx 5.10^4/\text{sec}$, which should be reduced to $\approx 300/\text{sec}$ by multilevel processing. Fastbus was found ideally suited to accommodate such a data acquisition system, because of its flexible data transfer possibilities at a high speed.

A symbolic diagram of the system is shown in Fig. 1. It is a two crate arrangement, with approximately thirty modules of twelve different types. The modules are being designed by a collaboration of laboratories⁴⁾; it should become operational in July 1984.

Fig. 1. Blockdiagram of the Fastbus system for the experiment NA-31.

FDM = Display Module, MWPC = Multiwire Proportional Chamber Read-Out, LTR = Drift Time Recorder, FBM = Data Block Mover, Orsay Sqr = Sequencer, other items go without explanation.

The most important future application of Fastbus in Europe will undoubtedly be in the LEP experiments at CERN. A definite approval has been given to mount four experiments, named ALEPH⁵⁾, DELPHI⁶⁾, OPAL⁷⁾, and L3⁸⁾ at the Large Electron Positron accelerator (LEP). These experiments are being prepared by collaborations with over 200 scientists from more than 30 different laboratories, mainly situated in Europe, but also in China, Japan, the US and the USSR.

The accelerator is scheduled to be completed in 1988, and it is the intention to install the experiments as soon as allowed by the construction of the accelerator, in order to be ready in time for the first accelerated particles. The detectors in these experiments are gigantic and have each 100,000 to 200,000 detector channels. They will be located in restricted areas at a minimum of 60 m below the surface. The budget of each of these experiments is approximately 75 MSF, and a large fraction ($\approx 35\%$) will be invested in electronics and on-line computers.

Three of the four LEP collaborations (ALEPH, DELPHI, L3) have decided to base their data acquisition systems on Fastbus, whereas the fourth (OPAL) plans to build its central detector read-out system to Fastbus specifications. All collaborations have a certain stock of CAMAC and NIM modules, which of course will be used wherever possible. New designs and purchases however will be mostly in Fastbus.

The motivation for choosing Fastbus for front end electronics (ADC, TDC, etc) is primarily because the valid data is sparsely distributed over the detector channels, and Fastbus offers the possibility to scan these channels at high speed. Filtered and formatted data from the front end electronics is then buffered and made easily accessible for second, third and possibly higher level trigger processors and emulators. In this part of data acquisition systems it is essential that data can be efficiently transferred between the various buffers and processors. Here, Fastbus offers the required large addressing space, high speed, multimaster capability with flexible arbitration, a segmented structure allowing undisturbed parallel processing and setting up of data routes, etc.

Various general purpose Fastbus modules are under discussion, such as buffer memories, data routers, spies, datablock movers, processors, etc.

The number of Fastbus crates in each of these experiments is estimated to be 150 to 250. In view of the limited space available, installation and cooling are major issues.

General purpose Fastbus developments

Hardware

The main Fastbus design activity at CERN has been devoted to providing so-called starter kits to groups that wanted to start using Fastbus, and to the design of general purpose CAMAC to Fastbus interfaces.

The starter kit is composed of the following elements: crate with power supply and cooling⁹⁾, ancillary logic boards¹⁰⁾, CAMAC to Fastbus interface FIORI (European version of IORFI¹¹⁾) and CAMAC I/O register¹²⁾, active extender board¹²⁾, bus monitor¹²⁾, Fastbus display module with test box extension¹²⁾, kluge boards with or without bus interface¹²⁾ and software (Fastbus extensions to ESONE CAMAC Fortran

subroutine calls). Over twenty five of these starter kits have been produced and are serving as a basis for the first wide spread Fastbus development in Europe. A symbolic diagram of a starter kit implementation is shown in Fig. 2.

Fig. 2. Blockdiagram of Fastbus starter kit and its connection via CAMAC to a host computer.

The design of a general purpose CAMAC to Fastbus Interface (CFI) is now completed. This device is based on the M68000 for port to port control and the AMD 2910 for handling the external bus protocols. It contains a buffer memory to decouple the CAMAC and Fastbus cycles, and offers therefore a higher instantaneous data throughput than the FIORI. A number of these units will be produced before the end of 1983. The CFI has a modular structure and can therefore easily be modified to interface to other computers or busses.

Further general purpose modules that have been completed or are nearing completion are a Service Request handler, a Fastbus sequencer to test modules at full speed, a general purpose master¹³⁾ based on the M68000, a REMUS¹⁴⁾ to Fastbus buffer, a data block mover, etc.

A cable segment driver circuit has been designed¹⁵⁾ and is now commercially available as a hybrid circuit¹⁶⁾. It contains four twisted pair drivers with characteristics according to the Fastbus specifications.

An active part has been taken by CERN¹⁷⁾ in the design of a monolithic chip set to handle the Fastbus protocol in modules. The set will consist of three Motorola macrocell circuits completed by some standard bus transceivers.

Crates, power supplies and cooling have been studied and designed as one entity. In particular the cooling has received careful study. After the experience in UA-1 and other experiments at CERN it has become clear that a closed loop rack based cooling system, feeding crates in parallel with a single big

heat exchanger and ventilator, is not well suited for high density electronics, as it proved difficult to control the air flow. Therefore a distributed system, with a fan tray and a heat exchanger per CAMAC crate has been proposed¹⁸⁾ and will shortly be implemented in UA-1. Based on the same principle a cooling system has been designed for Fastbus crates¹⁹⁾. Here, a 1.5 U high water cooled heat exchanger and a 1.5 U fan tray are mounted below each crate (9 U). Heat exchanger, fan tray and crate can be stacked to fill a rack, thus providing a single serial path for the air. The hot air leaving the top of a crate is cooled before entering the bottom of the next crate to cancel the accumulated temperature increase ($\Delta T \leq 70^\circ\text{C}$). The supplies are mounted behind the crates and are also covered by the heat exchanger. The total air flux is 1300 m³/h and it can handle a total 3 KW/crate (2 KW in modules, 1 KW in supply). The air in a rack is circulated in a closed loop. To this extent a special fan tray with two tangential blowers drives the air from the top crate via air ducts in the side of the rack to the bottom. Compared to the earlier system a better control over the air distribution and a lower noise level (≤ 66 db) have been obtained. Industrial production of crates, supply, cooling system and racks is in preparation.

Software

The Fastbus software development in Europe²⁰⁾ has until now been concentrated at CERN. It has consisted mainly of implementing the "standard" Fastbus routines for the FIORI and CFI interfaces operating as masters. Software is now available for the following host computers: PDP11, VAX, ND100, M68000, HP2XXX. The starter kits are creating a drastic increase in the demand for software support and it has been realized that a coordinated major effort on Fastbus software will be needed to support future hardware developments.

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