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About the Author

Graduated in Computer Science in 1985 at the Turin University, Dipartimento di Informatica, Roberto Divià joined CERN in 1987. His activities involved small acquisition and control systems, with particular interest for embedded microprocessors, front-end buses and fast data links. Currently he is an active member of the Data Acquisition team for the ALICE collaboration at CERN.

Recent Mezzanine Applications at CERN

Enrico Bravin and Bernd Dehning, SL-BI
Andrew Butterworth SL-RF
Martin Merkel IT-CE

Application-specific daughter or piggyback boards ("mezzanines") are a convenient way to customize systems. Depending on the standard, one can install 1-6 of them on carrier ("mother") boards and therefore implement different functions and local processing in a single slot of a bus-based system. From the some 30+ mezzanine specifications that exist in a range from proprietary to approved standards, CERN has endorsed two: IP-Module (ANSI/VITA–4, 1996) and PCI Mezzanine Cards (PMCs, IEEE–1386.1) *. The three chapters of this article illustrate how suitable industry-standard mezzanines are to provide solutions in areas as varied as high-speed data-acquisition with local processing, and industrial controls.

Beam–Diagnostic System with IP–Modules

The choice. Silicon–strip detectors, each of them containing 16 strips, generate the signals for the LEP (Large Electron Positron collider) luminosity monitors. A solution based on standard mezzanine products from industry has been chosen to build a high-speed data–acquisition system with local data processing on intelligent carrier boards. The first alternative was to use PMCs for two reasons, (i) compatibility with the LEP control system, and (ii) higher performance of the PowerPC–based PMC carrier boards. But, analog–to–digital converters (ADCs) with the required resolution, conversion speed, and number of channels per mezzanine did not exist as PMCs, and therefore the decision was to build the system with IP–Modules and intelligent (68040 microprocessor based) IP–carriers.

The system. Figure 1 shows the implementation with a trigger path ("Fast Trigger Decision") and the measurement path ("Collinearity Detection"). In the trigger path, two HiADC IP–Modules (12–bit resolution ADCs, 16 channels, 1.2 microseconds conversion time) convert the signals from eight detector channels and compare the results with threshold values for the generation of trigger signals. This happens every 22 microseconds. The IP–24, a digital input/output module, counts events and produces trigger and timing signals. Upon a trigger, the measurement path converts and analyzes 16x4 detector signals. Both paths use intelligent IP–Module carriers, 68040–based single–board VMEbus computers (MVME162). The conversion time of 1.2 microseconds is longer than the 0.8 microseconds required readout time. Therefore, in each path there are two sets of converters with alternating read out cycles.

The outcome. At the beginning of the project, the HiADC design changed ownership (from Wavetron to GreenSpring Computers) and underwent a redesign to bring it in line with other products from the same company. This caused some teething problems. After they had been solved (bug fixes and documentation clarification), the system behaved as expected. Following that experience, IP Modules have been used (i) for a test bench to acquire the magnetic field time evolution of an iron–concrete LEP dipole magnet and (ii) for the LEP NMR monitoring system.

Use of IndustryPack GPIB Interface Modules in the LEP RF System

Introduction. There are 22 radio–frequency (RF) acceleration units installed at four of the straight sections in the LEP ring. Each RF unit consists of:

- up to 16 cavities,
- up to four cryostat modules,
- one or two klystrons,
- one high voltage power converter,
- a waveguide system for RF power distribution
- all the associated high and low power electronics.

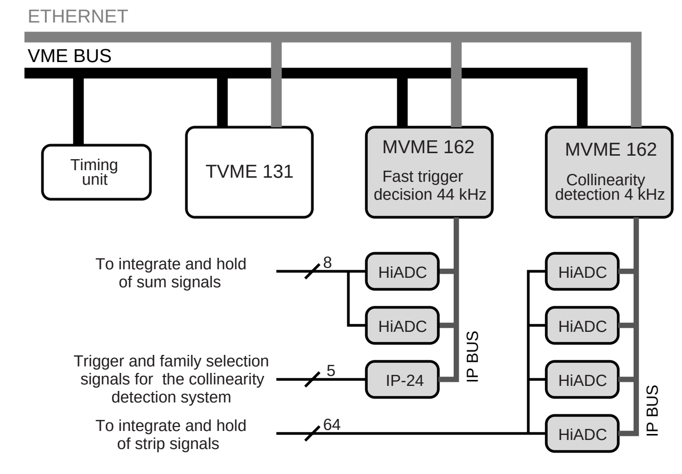

Figure 1: Beam-Diagnostic System with IP-Modules

Associated with each equipment (cavity, cryomodule, klystron, etc.) is an Equipment Controller (EC) crate containing the interface electronics for that equipment (see Figure 2). The ECs are based on the G64 bus and have a Z80– or 68030–based crate controller which performs simple tasks such as reading and setting of equipment values and surveillance of equipment. There are up to 27 ECs in each RF unit. They are connected via two General Purpose Instrumentation Buses (GPIB) to one Data Manager (DM) crate, a VME system with a 68040 SBC (single–board computer) running disk–based OS–9. The DM performs command–response message passing between the ECs and UNIX control room applications, runs local tasks launched via remote proce-

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*) *Recently, the inventors of the IP-Module and the M-Module mezzanine standards have joined forces to propose a new mezzanine specification, PC•MIP. A brief overview of the proposed standard is in the "News" section of this newsletter.*

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dure calls (RPCs) from the control room software, and hosts local applications such as RF conditioning of cavities and a touch screen interface for local operator control.

The General Purpose Instrumentation Bus. GPIB (specified in the IEEE–488 standard) is an 8–bit parallel bus commonly used on test equipment. It

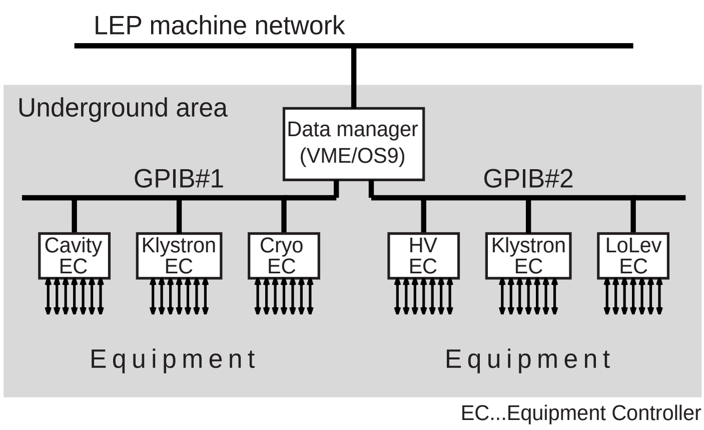

Figure 2: Controls layout within an RF unit

allows up to 15 intelligent devices to share a single bus, with the slowest device participating in the control and data transfer handshakes to drive the speed of the transaction. The maximum data rate is about one megabit per second. In the LEP RF system GPIB is used as a fieldbus for connection of the EC crates to the DM.

Upgrade of the Data Manager GPIB Interfaces. The GPIB interfaces in the ECs are implemented using a CERN–designed G64 board based on the Texas Instruments TMS9914 GPIB controller. However, for the DM things are more complicated. Before LEP startup in the late 1980s no VME GPIB interface was available, and a solution was adopted which involved interfacing a G64 GPIB card to the VME crate via a Themis TSVME101 slave processor board which has a G64 interface implemented on its P2 connector. This system worked reasonably well in the original copper unit DMs, which used a slow 68020–based crate controller. But, for the SC units installed since 1992 the DM used faster 68040–based controllers and timing–related problems were seen with the slave processor boards, making frequent reboots necessary. It was thus decided to replace the GPIB interface with a commercial board. The format of the Greenspring IP–488 was convenient as it allowed two GPIB interface modules on a simple–slave carrier board (VIPC610) to be installed in one VME slot. Driver software for OS–9 using the IBF filemanager from Ark Systems was available off the shelf. A new equipment access library using the IBF C–language interface was written for the DM software as a drop–in replacement for the original one.

Results. The move to the IP–488 interfaces has solved the problems we experienced with our old slave– processor–based system, and simplified the physical layout of the DM chassis, resulting in a considerable improvement in reliability.

CANbus IP Modules

Controller Area Network (CAN), a serial bus system originating from Robert BOSCH GmbH in Germany and developed for the automobile industry, is becoming increasingly popular as a flexible interface to industrial control devices, like sensors and actuators. CANbus links are also candidates to replace proprietary control interfaces in high–voltage power supplies and intelligent fan–trays for electronics subracks. CANbus supports distributed real–time control with a high level of security at bit rates up to 1Mbit/s. In 1993 CANbus became an international standard, described in the ISO 11898 document. Together with ProfiBus and WorldFIP, CANbus has been selected by the Working Group on Fieldbuses as a CERN standard.

Architecture Overview. CAN is subdivided into three different layers. The functionality of the CAN object and the transfer layers corresponds to the data link layers of ISO/OSI model (Figure 3).

Object Layer:

- Message Filtering
- Message and Status Handling

Transfer Layer:

- Fault Confinement
- Error Detection and Signaling
- Message Validation
- Acknowledgement
- Arbitration
- Message Framing
- Transfer Rate and Timing

The ISO 11898 document consists of the original CANbus specification and the physical layer which originally was not part of CANbus.

CAN is a multimaster bus system that uses a CSMA/CA (Carrier Sense, Multiple Access with Collision Avoidance) mechanism for the bus arbitration. The concept of directly addressing subscribers or nodes does not exist in CAN. Each node uses an unique identifier, contained in a CAN frame (content–oriented addressing), to decide whether it has/has not to process the message (based on acceptance masks). The identifier also determines the priority of messages.

In the first version of the CAN specification eleven bits were reserved for the identifier (Standard CAN). The current specification (CAN Rev. 2) also allows for an identifier field of 29 bits (Extended CAN), offering more flexibility in the addressing scheme. Both Standard (Rev. 2A) and Extended CAN (Rev. 2B) nodes can communicate with each other on the same physical bus, provided that only 11–bit identifiers are used. There is the notation of Rev. 2B passive nodes—limited to 11–bit identifiers—which are able to detect and ignore messages in the extended CAN format.

In addition to the identifier and various other control fields, each CAN frame contains up to eight data bytes.

CANbus Protocols. As described above, the CANbus specifications define only the two lowest layers of the ISO/OSI reference model. In order to provide the functionality corresponding to the ISO/OSI application layer, various protocol definitions have emerged. Further abstraction is provided by device profiles like CANopen. It is based on CAL (CAN Application Layer), one of the protocol standards.

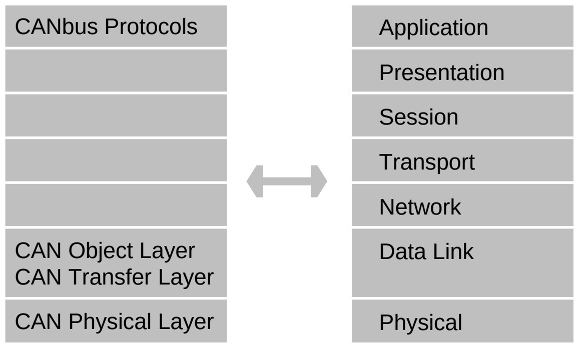

Figure 3: CANbus structure and corresponding layers in the ISO/OSI reference model.

IP Modules. CANbus interfaces are available in different form factors, like PCI cards, PCI Mezzanine cards (PMCs), and IP Modules. Control systems for LHC experiments will need a large number of sensors, connected to multiple independent fieldbus networks. Keeping that in mind, we started an evaluation of two CAN IP–Modules, available from Tews DATENtechnik GmbH. We choose IP modules, because their small size allows for high integration. Up to four independent bus interfaces fit on one VMEbus carrier board. The modules selected are the TEWS TIP810 and TIP816. The

More information on mezzanines and support at CERN is available on the Web at: http://wwwinfo.cern.ch/ce/ms/mezzanines/

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TIP810 is based on the Philips PCS82C200 CAN controller. It supports standard data and remote frames according to the CAN specification Rev. 2A. The TIP816 uses the Intel 82527 chip, which handles both standard data and remote frames according to Rev. 2A, as well as extended data and remote frames described in CAN Rev.2B.

In our test setup the TIP816 is mounted on a Motorola MVME162–533 embedded controller. The TIP810 is installed on a GreenSpring VIP610 IP slave carrier board controlled by a Motorola MVME167 single board computer. Both processor modules are running OS–9 3.0 and driver software delivered by Tews DATENtechnik. The two CAN interfaces are connected to a common bus, together with a WIENER NIM/CAMAC fan–tray conforming to CAN Rev. 2A.

Using the test software provided with the IP–Modules, we verified that both standard and extended CANbus interfaces can reliably communicate with each other, provided 11–bit message identifiers are used. In a mixed network, care has to be taken not to transmit extended CAN frames, because standard CAN nodes (like the TEWS TIP810) will signal an error condition if they encounter a 29–bit identifier (no Rev. 2B passive!).

In a second step we modified the example code to allow us to perform simple control tasks, like changing the fan speed of the fan–tray or to turn it on or off.

Conclusions. IP Modules appear as an attractive solution when highly integrated interfacing to CAN fieldbus networks is required. Already, there are the first products announced that will offer three independent CANbus interfaces on one single–width IP Module.

Drawbacks are that software support is essentially limited to a level–2 interface according to the ISO/OSI reference model and popular real–time operating systems. Application layer software, like CAL or CANopen, might become available in the near future. Currently, there is no driver support for Windows NT, nor for higher–level application software, like LabView or BridgeView from National Instruments.

IT–CE Staff Movements

Christoph Eck, IT–CE

In the last newsletter I announced that Antonio Jimenez de Parga Bernal had joined CE Group as technical student. By now he has left us already. Having obtained his engineering diploma in early summer, he got a very nice job offer from the European Space Agency research centre in Noordwijk in the Netherlands. He started his work there at the beginning of September.

Three more technical students left the group in mid summer, this time after the longest possible stay at CERN. Colin Price went back to Bristol to finish his studies, whilst Asuncion Aguilar Perez and Francisca Zanoguera have by now both graduated as engineers. Asuncion is now working in the IT department of SHELL who plan to send her to Argentina, profiting from her Spanish mother tongue. Francisca just told us that she received a scholarship to do a Ph.D. at the "Centre de Morphologie Mathematique" of the famous "Ecole de Mines de Paris".

I find it very satisfying to see that many of our technical students have excellent job opportunities after leaving CERN. Let me thank this lot for the help they gave us. I am looking forward to the next selection committee in December where I hope to fill up our by now depleted ranks.