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The Use of Mezzanines at CERN[1]

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Abstract

Mezzanines have become the latest trend in modular electronics and this paper describes their use at CERN. At first, the paper introduces the mezzanine concept and gives an overview of the current market and standardization situation. Then it mentions application areas at CERN, lists the criteria that lead to endorsing two specific mezzanine standards, and gives application examples. Finally, some conclusions will be drawn.

Introduction

In recent years, a trend toward increased modularity of electronic equipment has become popular. The concept ("mezzanine concept") is to use general-purpose base boards that carry application-specific mezzanine boards.

Base boards, or carrier, or mother boards, provide common infrastructure features (e.g., backplane-bus interfacing, compute resources, networking capabilities, etc.) for the mezzanines connected to them. Mezzanines are also known as daughter boards or piggy-backs. Both carriers and mezzanines follow a "mezzanine-bus" specification which defines the mechanics, the electrical, and logical layers.

Carriers exist as "intelligent" (with an onboard processor) or "dumb" (slave-only capability) boards. One finds standalone or bus-based (e.g., VMEbus, etc.) carriers. The mezzanines perform application-specific functions, such as analog-to-digital conversion (ADC), digital input/output, graphics, communications, etc.. Carriers and mezzanines exist in different sizes (form factors). Examples are 3U- or 6U-sized VMEbus carriers, and single- or double-width mezzanines, with or without frontpanel option. Typically, carriers can accommodate 1–4 mezzanines. This gives users an easy way to customize their system with off-the-shelf components.

The Mezzanine Market

Industry has shunned the use of mezzanines for some time. Among the reasons for doing so were potential reliability problems, due to the additional connectors, and commercial issues. But, factors, like the success of VMEbus, reliable connectors, higher-level integration, smaller-sized components, high per-slot cost of modules, etc., helped to change that situation. One could observe a proliferation of mezzanine products and specifications. In 1991, VITA (VMEbus International Trade Association) conducted a survey on mezzanines. In reply to the survey, thirteen companies sent their mezzanine specifications. Some of these specifications were multi-vendor supported and in the public domain. Others were proprietary and supported by a sole source, the inventor of the specification. In such a market situation, users still can benefit from the finer-grained modularity that mezzanines offer. But, they also risk locking themselves to a particular manufacturer (e.g., the 1995 VMEbus Product Directory[1] lists 30 vendors of company-specific mezzanine modules). This has been recognized and standardization efforts are under way. Currently, three mezzanine standards are being prepared under the VITA Standards Organization (VSO) and one under the Institute of Electrical and Electronics Engineers (IEEE):

- VITA 4-1995 - IP Modules[2]: Its origin is the IndustryPack® specification from GreenSpring Computers (USA), introduced in 1988 at the BUSCON conference as an open standard. At the beginning of 1994, a formal standards committee was set up and VSO became the public domain administrator of the specification. A working-group ballot took place in April 1995 and an ANSI (American National Standards Institute) ballot is targeted for the second half of 1995.
- VITA 12-199x - M-Modules[3]: This specification originated 1988 from MEN Mikro Elektronik (Germany). In 1992, the international trade association MUMM (Manufacturers and Users of M-Modules) was founded to develop the cooperation of manufacturers and to integrate user requirements. VSO supports and administers the standardization process. A task group ballot was completed and the comments were sent back to the working group for revision.

[1]CERN, the European Laboratory for Particle Physics, has its headquarters in Geneva, Switzerland. At present, CERN counts 19 Member States. Four countries, the European Commission, and UNESCO have observer status. The laboratory is open for visits to the public. Guided tours take place on Saturdays at 9 hrs and at 14 hrs. Group visits can be arranged during the week. Call +41.22.767 8484 or fax +41.22.767 8710 to book a visit or to obtain more information.

- VITA 14-199x - CXC / ModPack[4]: PEP Modular Computers (Germany) introduced the Controller eXtension Connector to extend host microprocessor lines (address, data, control) onto plug-in mezzanine boards. VSO supports and administers the standardization process.

- IEEE P1386.1 - PMC[5]: This draft standard is a combination of two specifications, (i) the PCI (Peripheral Component Interconnect) Local Bus[6] for the electrical and logical layers and (ii) the CMC (Common Mezzanine Card) specification[7] for the mechanics. Originating from Intel, PCI is now an industry standard and has become the local bus of choice in modern single-board computers. The PCI Special Interest Group (PCI-SIG) maintains the specification. CMC (proposed standard IEEE P1386.0) defines the mechanics for a common set of low-profile mezzanine cards. A ballot for both CMC and PMC has just taken place.

Mezzanines at CERN

Since the early days of modular electronics, mezzanines have been in use at CERN. Designers called them piggybacks or daughter boards. One found them primarily in frontend electronics, e.g., for analog-to-digital conversions. Mother and daughter boards conformed to a design(er)-specific "ad hoc" protocol. The main objective was to pack as many frontend channels as possible onto a mother board, in order to reduce the per-channel cost of interfacing to a backplane bus.

At CERN, users recognized the advantages of commercial mezzanine products and demand began to grow. Given the fragmented market situation, the potential for proliferation of incompatible products existed and the need to provide guidance for users arose. Looking at possible application areas at CERN, one can find a whole spectrum, ranging from simple industrial I/O to very-high bandwidth applications. It appeared, that, at least for the time being, no single mezzanine standard could cover this spectrum. Therefore, CERN's VMEbus Steering Committee (VSC), the coordinating body for the laboratory's VMEbus activities, has endorsed two mezzanine families: PMC and IP-Module.

PMC, as mentioned above, has become an industry standard. Its peak data transfer rates of 132 Mbytes/s (for 32-bit wide implementations) or 264 Mbytes/s (for 64-bit wide implementations) and the momentum which it has gained in industry made it the obvious candidate for high-bandwidth applications.

IP-Modules, with their smaller size and simpler protocol, are intended to cover application areas with less-stringent bandwidth requirements. The peak data transfer rate for IP-Modules is 64 Mbytes/s (32 MHz clock version and 32-bit wide implementation). The principle reasons to select IP-Module over other mezzanine specifications were the following:

- Form Factor: two mezzanines fit onto a 3U VMEbus board and not only one, as for other specifications.

- Electrical Characteristics: the larger number of ground and power pins (as compared to other specifications) gives more "design headroom".

- Logic Interface: the identification PROM is mandatory. This feature is necessary for the auto-configuration of systems.

- Market Acceptance: the choice had to be acceptable to the institutions that participate in CERN's physics program from different parts of the world.

- Software Issues: intelligent IP-Module carriers are among the reference platforms of CERN's two main real-time operating system providers (Lynx Real Time Systems for LynxOS and Microware for OS-9).

Somewhat controversial issues were:

- Form factor: other mezzanine boards are larger, providing more real estate for applications.

- I/O connector: IP-Modules use a defined 50-pin connector for I/O. Other specifications leave the choice of the I/O-connector open.

Applications at CERN

At CERN, one can distinguish between two broad categories for mezzanine applications: (i) upgrading existing systems with standard-off-the-shelf mezzanine products, and (ii) using mezzanines as a convenient base for in-house designs.

Upgrading Existing Systems

Under this first category, users add functionality to existing systems or replace obsolete hardware with mezzanines. Usually, the existing system already has a compute platform with networking capabilities, among other standard features. Therefore, simple slave boards are the typical carrier choice for mezzanines, as illustrated in the following examples.

Example 1[8]: Remote monitoring and control of power supply systems from a VMEbus system. The experiment has a cluster of 660 power-supply channels, installed in a total of six special crates. Each crate has a control and monitoring unit with a RS485 interface. A single serial link connects the control units of three power-supply crates to a VMEbus system. Each of the two links (to control the six crates) consists of two RS485 channels for full duplex communication, operating at a rate of 125 kBauds. On the VMEbus side, a single-wide IP Module (TIP865-30) drives both links. A small in-house designed transition board, with two DB-9 connectors on the front, plugs into the input/output connector of the slave carrier board. It biases (for the quiescent state) and terminates the transmission lines. The operating system is OS-9 and the software driver for the TIP865-30 was purchased from the manufacturer.

Example 2[9]: Communication and controls link between slave crates for radio-frequency (RF) equipment and VMEbus systems. Small crates (G64) house the control electronics for RF equipment used in particle accelerators (RF cavities). The communication link between the G64-crates and the supervisory VMEbus system is the instrumentation bus IEEE-488. For new installations, and as a replacement for existing ones to obtain a uniform structure, an IP-Module solution has been chosen. From a single VMEbus slot, and under OS-9, two IP-488 modules on 3U or 6U carrier boards (VIPC310, VIPC610) control two independent instrumentation buses. The OS-9 driver for the IP-488s was purchased.

Example 3[10]: In particle-physics experiments, one finds certain industrial-control-like applications ("slow controls"), such as systems to control the flow and the composition of gas mixtures for detectors, or access control and safety systems. In this example, two IP Modules (IP-OptoDriver, IP-Digital 24), mounted on a simple-slave carrier board (VIPC610), provide a single-slot solution. The IP-OptoDriver controls valves of a gas-mixture system, and the IP-Digital 24 provides inputs/outputs for an in-house designed safety system ("Black Box L3"). The experiment uses the OS-9 operating system. Drivers and descriptors for these channel-oriented devices were written in-house in assembly code.

Example 4[11]: Similar to the example above, the NA48 experiment is installing IP Modules for industrial I/O applications. Opto-isolated switches (IP-OptoDriver) control valves, relays, VMEbus power supplies, and the reset functions for computers and VMEbus equipment (via the VMEbus SYSRESET line). In places where only a few analog channels are needed, the experiment will use analog input/output mezzanines (IP-ADIO) with additional capabilites (insulated digital I/O and timer functions). Other modules (IP-OptoInterrupter) act as switch sensors (e.g., crate status, range-limiting microswitches), generating interrupts for the supervisory software. Platinum sensors (PT100) serve to precisely measure the temperature of critical electronic equipment. The signal conditioner for the sensors is a mezzanine device (IP-RTD). All mezzanines operate from simple VMEbus slave carrier boards, under the LynxOS operating system. One software driver was purchased, the others were written in-house.

Mezzanines: Base for In-house Designs

This second category looks at mezzanines as an interesting option for in-house developments. As mentioned in the introduction, carrier boards provide infrastructure features, like networking capability, backplane-bus interface, compute resources, graphics, etc.. If engineers base in-house developments on mezzanines, they can take advantage of these existing features, without having to (re)design them. The following examples illustrate this category.

Example 1[12]: PCI-SCI (Scalable Coherent Interface, IEEE Std 1596) bridge for high-rate data-acquisition architectures. Data-acquisition systems for next generation particle-physics experiments will process data from millions of detector channels. Studies are under way to come up with suitable, layered architectures which can filter and process massive amounts of data and are based on industry standards. In this project, the SCI serves to interconnect a large number of data producer and consumer nodes. VMEbus computers and digital-signal-processing engines, with PCI as the local bus, will receive data from the detectors, process the data, and move them via SCI to the next-level consumers. A research and development project is to build a PCI-SCI bridge. Certain features of this bridge, like direct memory access, transparent memory access (i.e., mapping address windows of this bridge into SCI), multi-cpu support, and dual-ported data flow on the consumer side, are of particular importance.

Example 2[13]: PCI-HIPPI high-speed data link. This project consists of building a PMC as a high-speed data link between PCI and HIPPI for next-generation particle physics experiments.

Example 3[14]: Triple-ported IP-Module memory mezzanine. In data-acquisition systems, the primary function of dual-port memories is to buffer data from frontend sensors, before transferring them through a fast switching network to an event-building processor farm. For this particular application, a VMEbus based dual-ported memory module has been designed. It carries in-house developed memory mezzanines with fast input and output ports. Their third port is a control port that complies with the IP-Module specification.

Conclusions

The increased level of modularity which mezzanines offer, combined with a good selection of commercially available functions, have lead to a growing number of applications at CERN, in particular for industrial-control-type applications.

It is felt that, for the time being, IP-Modules and PMCs address different segments. The basic distinction is band-width requirements, but some overlap exists.

Besides the standard applications to upgrade or to expand existing systems with commercially available products, mezzanines also offer an interesting solution for in-house developments. Designers can concentrate on the implementation of specific functions, without having to worry about infrastructure features (e.g., processor, networking, etc.) which are readily available on carrier boards. Work is under way to define the requirements and to evaluate the potential for high-energy-physics specific carriers and mezzanines. This approach could help (i) to reduce the number of different standards used in data-acquisition systems (e.g., CAMAC, NIM, VMEbus, etc.) and (ii) to facilitate the migration from one standard to another.

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References

[1] "VMEbus Products Directory." 1995. VITA, Phoenix, Arizona.

[2] "IP Modules, Draft Standard VITA 4-1995." 1995. VITA, Phoenix, Arizona.

[3] "M-Modules Specification, VITA 12-199x." 1995. MUMM, Nürnberg, Germany.

[4] "CXC/ModPack, VITA 14-199x." 1995. PEP Modular Computers, Kaufbeuren, Germany.

[5] "P1386.1 Proposed Standard Physical and Environmental Layers for PCI Mezzanine Cards." April 1995. IEEE, Piscataway, New Jersey.

[6] "PCI Local Bus Specification." Revision 2.0, April 1993. PCI Special Interest Group, Hillsboro, Oregon.

[7] "P1386.0 Proposed Standard for a Common Mezzanine Card Family." April 1995. IEEE, Piscataway, New Jersey.

[8] F. Meijers, S. De Jong. 1995. "Private Communication." CERN, Geneva, Switzerland.

[9] A. Butterworth, E. Ciapala. 1995. "Private Communication." CERN, Geneva, Switzerland.

[10] H. Milcent, R. Stampfli. 1995. "Private Communication." CERN, Geneva, Switzerland.

[11] R. Fantechi. 1995. "Private Communication." CERN, Geneva, Switzerland.

[12] A. Bogaerts, C. Fernandes, L. McCulloch, H. Muller, P. Werner. 1995. "A PCI-SCI Bridge for High-rate Data-Acquisition Architectures at LHC." In Proceedings PCI'95 (Santa Clara, California, March 27-31).

[13] R. McLaren, A. Van Praag. 1995. "Private Communication." CERN, Geneva, Switzerland.

[14] A. Fucci, D. Gigi. 1995. "Private Communication." CERN, Geneva, Switzerland.