Using PC/104 Embedded-PC Modules for Embedded Applications

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THE NEED FOR EMBEDDED SYSTEM STANDARDS

Over the past decade, the PC architecture has become an accepted platform for far more than desktop applications. Dedicated and embedded applications for PCs are beginning to be found everywhere! PCs are used as controllers within vending machines, laboratory instruments, communications devices, and medical equipment, to name a few examples.

By standardizing hardware and software around the broadly supported PC architecture, embedded system designers can substantially reduce development costs, risks, and time. This means faster time-to-market and hitting critical market windows with timely product introductions. Another important advantage of using the PC architecture is that its widely available hardware and software are significantly more economical than traditional bus architectures such as STD, VME, and Multibus. This means lower product costs.

For these reasons, companies that embed microcomputers as controllers within their products seek ways to reap the benefits of using the PC architecture. However, the standard PC bus form-factor (12.4" x 4.8") and its associated card cages and backplanes are too bulky (and expensive) for most embedded control applications.

The only practical way to embed the PC architecture in space- and power-sensitive applications has been to design a PC — chip-by-chip — directly into the product. But this runs counter to the growing trend away from "reinventing the wheel." Wherever possible, top management now encourages out-sourcing of components and technologies, to reduce development costs and accelerate product design cycles.

A need therefore arose for a more compact implementation of the PC bus, satisfying the reduced space and power constraints of embedded control applications. Yet these goals had to be realized without sacrificing full hardware and software compatibility with the popular PC bus standard. This would allow the PC's hardware, software, development tools, and system design knowledge to be fully leveraged.

PC/104 was developed in response to this need. It offers full architecture, hardware, and software compatibility with the PC bus, but in ultra-compact (3.6" x 3.8"), stackable modules (see Figure 1). PC/104 is therefore ideally suited to the unique requirements of embedded control applications.

A PROPOSED EXTENSION TO IEEE-P996

Although PC/104 modules have been manufactured since 1987, a formal specification was not published until 1992. Since then, interest in PC/104 has skyrocketed, with over a hundred different PC/104 modules introduced by more than three dozen manufacturers. Like the original PC bus itself, PC/104 is thus the expression of an existing *de facto* standard, rather than being the invention and design of a committee.

In 1992, the IEEE began a project to standardize a reduced form-factor implementation of the IEEE P996 (draft) specification for the PC and PC/AT buses, for embedded applications. The PC/104 Specification has been adopted as the "base document" for this new IEEE draft standard, called the *P996.1 Standard for Compact Embedded-PC Modules*.

The key differences between PC/104 and the regular PC bus (IEEE P996) are:

Compact form-factor. Size reduces to 3.6 by 3.8 inches.

Unique self-stacking bus. Eliminates the cost and bulk of backplanes and card cages.

Pin-and-socket connectors. Rugged and reliable 64- and 40-contact male/female headers replace the standard PC's edgecard connectors.

Relaxed bus drive (6 mA). Lowers power consumption (to 1-2 Watts per module) and minimizes component count.

By virtue of PC/104, companies embedding PC technology in limited space applications can now benefit from a standardized system architecture complete with a wide range of multi-vendor support.

TWO WAYS TO USE PC/104 MODULES

Although configuration and application possibilities with PC/104 modules are practically limitless, there are two basic ways they tend to be used in embedded system designs:

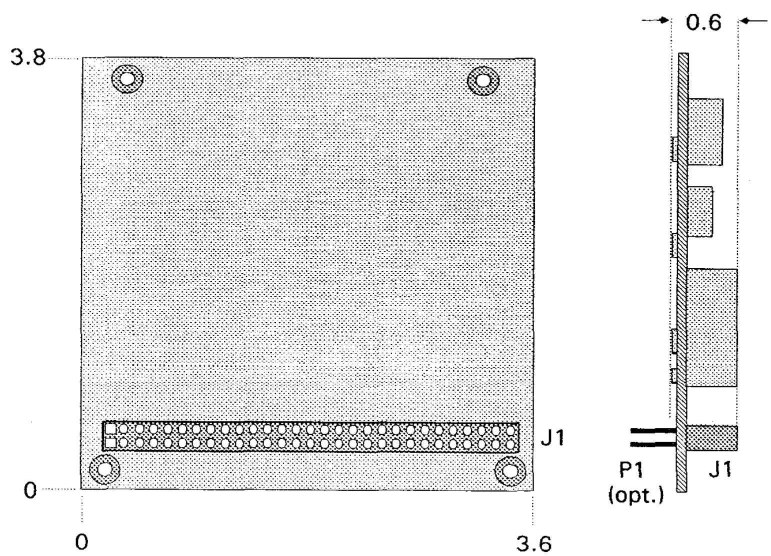

Figure 1. Basic Mechanical Dimensions (8-bit Version)

Standalone module stacks. As shown in Figure 2, PC/104 modules are self-stacking. In this approach, the modules are used like ultra-compact bus boards, but without needing backplanes or card cages. Stacked modules are spaced 0.6 inches apart. (The three-module stack shown in Figure 2 measures just 3.6 by 3.8 by 2 inches.) Companies using PC/104 module stacks within their products frequently create one or more of their own application-specific PC/104 modules.

Component-like applications. Another way to use PC/104 modules is illustrated in Figure 3. In this configuration, the modules function as highly integrated components, plugged into custom carrier boards which contain application-specific interfaces and logic. The modules' self-stacking bus can be useful for installing multiple modules in one location. This facilitates future product upgrades or options, and allows temporary addition of modules during system debug or test.

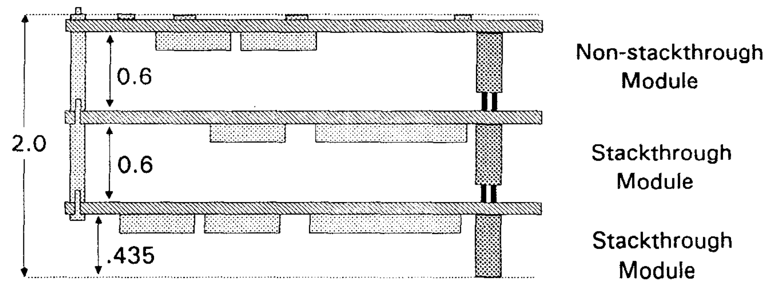

Figure 2. Standalone Module Stacks

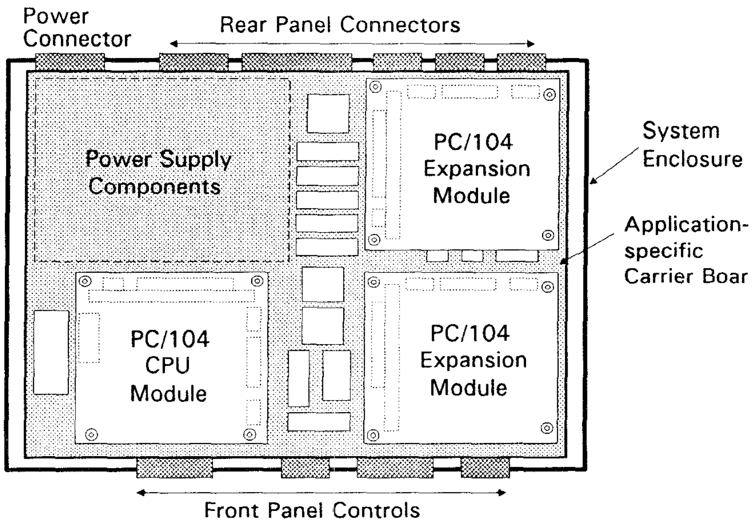

Figure 3. Component-like Applications

PC/104 SPECIFICATION OVERVIEW

Figure 4 shows the mechanical specifications of the 8-bit PC/104 module format. The PC/104 spec also defines a 16-bit module format. Each is 3.6 by 3.8 inches in size. The complete specification is available from the PC/104 Consortium (see reference, below).

BUS CONFIGURATION OPTIONS

There are four defined bus configuration options, for 8- and 16-bit PC/104 modules, as shown in Figure 5. This flexibility is needed to effectively meet the tight space constraints of embedded applications. These are the differences among the four bus variations:

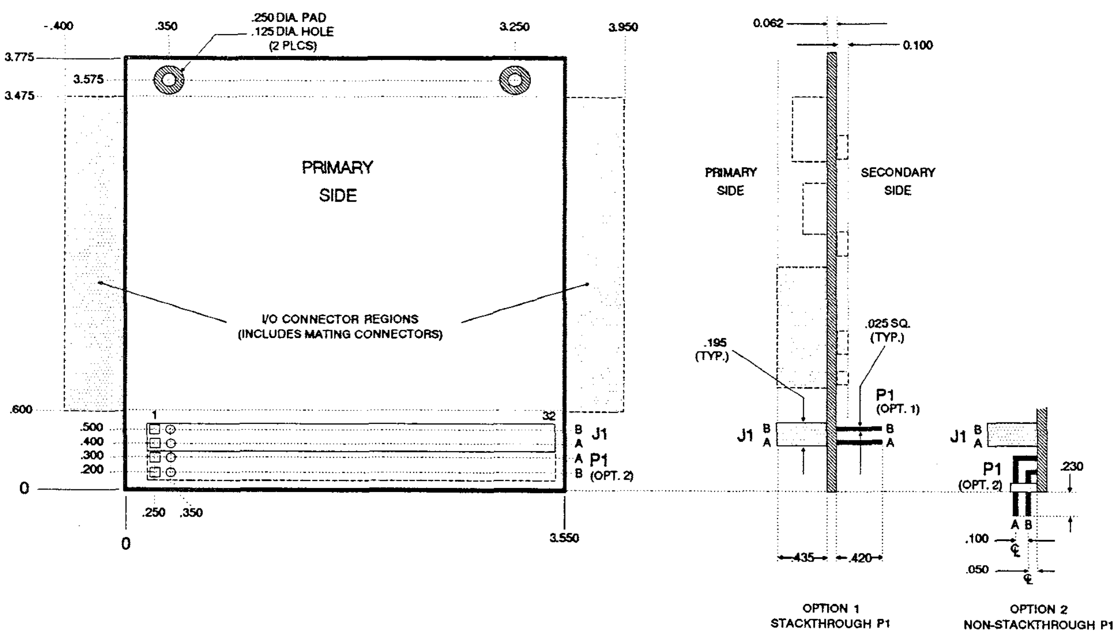

Figure 4. Detailed Mechanical Dimensions (8-bit Version)

8-bit, Stackthrough P1. This version has a self-stacking 8-bit PC bus. It can be placed anywhere in a multi-module stack.

8-bit, Non-Stackthrough P1. This version offers minimum module thickness, by omitting the P1 bus stackthrough pins. It must be positioned at one end of a stack. If required, additional bus expansion can be accomplished through the right-angle P1 connector. This module version cannot coexist in a stack with 16-bit, Stackthrough P2 modules.

16-bit, Stackthrough P2. In this 16-bit configuration, both the P1 and P2 bus connectors are stackthrough. This version eliminates the need for a P2 daisy-chain cable. This module version cannot coexist in a stack with 8-bit, Non-Stackthrough P1 modules.

16-bit, Non-Stackthrough P2. This 16-bit configuration has a stackthrough P1 bus connector and a right-angle P2 bus connector. It can be placed anywhere in a multi-module stack, and can coexist in a stack with 8-bit, Stackthrough P1 modules. A short ribbon cable is normally used to daisy-chain the P2 bus connectors of the 16-bit modules in a stack.

SIGNAL DEFINITIONS

PC/104 bus signals are identical in both name and function to their P996 counterparts. Only the following mechanical differences exist:

Connector Style. Instead of the P1 and P2 edgecard connectors, with 62 and 36 signal positions respectively, PC/104 modules use 64- and 40-pin pin-and-socket headers.

Signal Assignments. Signal assignments essentially correspond to the P996 edgecard connector pinouts, except transformed to positions on the P1 and P2 pin-and-socket header connectors.

Added Grounds. On P1, two grounds are added at the high-numbered end of the connector; on P2, two grounds are added at each end.

Key Pins. Two pins have been designated as key pins on P1; one on P2.

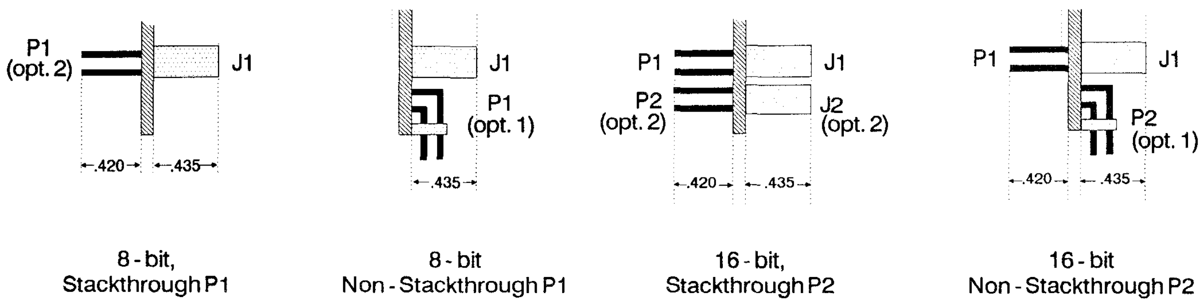

Figure 5. PC/104 Module Bus Options

ELECTRICAL CHARACTERISTICS

PC/104 bus signal AC and DC electrical characteristics are identical to those of P996, except as indicated:

Signal Timing. Identical to standard P996 (PC bus).

Logic Levels. Identical to standard P996.

Signal Termination. The AC termination method described in P996 is recommended, when termination is required.

Bus Sink Current. The requirement is reduced to 6 mA on most signals. This was done for several reasons:

1. Reduced bus drive results in lower power consumption and reduced EMI radiation.
2. Typical bus driver/receiver logic can be implemented with low power, controlled-slew-rate HCT devices, resulting in improved bus signal noise immunity.
3. Many VLSI devices can supply this bus drive without external buffering, thereby reducing overall component count.

THE "PC/104 CONSORTIUM"

To further the development of PC/104 products, support, and documentation, a multi-vendor consortium has been formed. Today, the PC/104 Consortium has over 80 members who offer over a hundred different PC/104 modules as well as a wide range of PC/104-related software and peripherals.

CPU modules are both PC- and AT-compatible. Interface modules include display and user-interface controllers, network adapters, digital and analog I/O interfaces, as well as a variety of special function interfaces. Other PC/104-oriented products include support software, enclosures and subsystem packaging, and bus connectors.

For information on PC/104, including copies of the PC/104 Resource Guide, PC/104 Specification, and details regarding membership, contact:

PC/104 Consortium
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