CompactPCI, Interconnect Solutions for Computer Telephony Integration

an adaptation of the Peripheral Component Interconnect (PCI) Specification

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CompactPCI, Interconnect Solutions for Computer Telephony Integration

The PICMG, (PCI Industrial Computer Manufacturers Group), is a consortium of over 450 companies who collaboratively develop specifications that adapt PCI technology for use in industrial and telecommunications computing applications. PICMG Specifications include CompactPCI, *(cPCI)*, for Eurocard, rackmount applications and PCI/ISA for passive backplane, standard format cards. This groups purpose is to offer industrial equipment suppliers common specifications, thereby increasing availability and reducing the costs of industrial PCI standard-based products.

CompactPCI is an adaptation of the *Peripheral Component Interconnect (PCI) Specification* for industrial and/or embedded applications requiring a more robust mechanical form factor than desktop PCI. CompactPCI uses industry standard mechanical components and high performance connector technologies to provide an optimized system intended for rugged applications. It provides a system that is electrically compatible with the PCI Specification, allowing low cost PCI components to be utilized in a mechanical form factor suited for rugged environments. *cPCI* specifies the 2 mm Hard Metric connector supported by the IEC-61076-4-101, Telephony Specification, Issued Feb. 1999, (ref. Bishop Report Type 2).

cPCI has developed into the defacto interconnect standard capable of addressing the numerous electro-mechanical issues associated with Computer Telephony Integration, (CTI), including printed circuit cards which have *hot swap* capability. CTI encompasses an entire industry, devoted to the closer integration of telephony systems with computer controlled devices. This industry has created a number of innovative products which interconnect tier 1 interfaces, fax and voice processing, voice-over-Internet Protocol (VoIP), and other peripheral devices. This equipment normally operates in industrialized chassis housings providing switch functions, voice-mail servers, automatic call distributors and other equipment types. Regarding the 2mm connector system at the heart of this bus interface, adoption by the telco's is equivalent to capturing the brass ring. Equipment integrators are now able to build rugged, high density systems with the added advantage of *hot swapping* in a more economic and efficient manner.

As in any system, backplane configuration is paramount to providing a scalable form factor. cPCI defines a new backplane technology that offers benefits to manufacturers based upon the combination of three key factors:

- PCI silicon support
- 2-mm industry standard connectors
- large form factor

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PCI is a personal computer bus standard that was developed by Intel to transfer data between the CPU and printed circuit cards at ~132 Megabits/sec as compared to its predecessor, ISA bus, which transferred data at ~5 Megabits/sec. PCI was introduced to standardize the chips selected for use on PC compatible peripherals and was unique in that it utilized silicon. Shortly after its' introduction, Intel was joined by many other vendors and PCI became the most common bus interface in the industry. In spite of its' popularity and high-speed data transfer, PCI was not deemed suitable for CTI applications because it lacked the higher densities available from VME systems. PCI could only support four cards within a system. CompactPCI offers a solution to this dilemma because it is based on the VME European form factor and provides a scalable format in 8 card increments.

cPCI uses a vertically mounted backplane consisting of five connectors, and is defined in the PICMG's CompactPCI specification 2.0. This method of mounting is significantly more robust that that available from a standard PC and provides improved thermal management as air can flow over and between PCB's & components more freely. Telecom applications use many *DSP's,* (digital signal processors), which tend to be heat intensive. Cooling these devices is a primary consideration regarding the components mean-time-between-failure, *MTBF*, and overall system reliability. Additionally, because of its vertically oriented backplane, PCB's can be plugged in from both the front and rear of the unit. Rear-plug-up PCB's will be discussed in more detail further on. The system form factor has been defined for both 3U (100 mm x 160 mm) and 6U (233 mm x 160 mm) card sizes and has the following features:

- Standard Eurocard Dimensions (complies with IEEE 1101.1 mechanical standards)
- High Density 2mm Pin-and-Socket Connectors (IEC approved & Telcordia qualified)
- Vertical Card Orientation for good cooling
- Positive Card Retention
- Excellent Shock and Vibration Characteristics
- Metal Front Panel
- User I/O Connections on Front or Rear of module
- Standard Chassis available from many Suppliers
- Uses Standard PCI Silicon Manufactured in Large Volumes
- Staged Power Pins for Hot Swap Capability
- Eight Slots in Basic Configuration. Easily expanded with Bridge Chips

Some integrators offer 9U PCB's at 367 mm x 400 mm, however, 9U implementations are not supported by the PICMG cPCI standard. Several connector configurations are used to support integration to the physical bus itself. Although different size connectors are used for each cPCI version, each connector serves a specific purpose and contains a specific number of 2-mm contacts (220 for 3U, and 315 for 6U). Regardless of board size, I/O terminations are predetermined and were established to provide access to power and ground, high signal integrity, minimal signal reflection, and minimal crosstalk. These fixed requirements are in contrast to the multiplicity of I/O pin arrangements that were allowed under other system standards and assures interoperability of the cPCI standard.

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At the heart of CompactPCI is a gas tight, high density pin-and-socket connector which meets the IEC-61076-4-101, Telephony Specification. This 2 millimeter "Hard Metric" connector has an external metal ground shield which augments its' electrical performance by providing a low inductance, controlled impedance medium which is ideal for PCI signal transmissions. These shields ensure adequate grounding for low ground bounce and reliable operation in noisy environments. This connector's controlled impedance minimizes unwanted signal reflections and enables CompactPCI systems to have eight slots, as compared to the desktop PC's four. As mentioned earlier, cPCI is completely scalable. These connectors, when used in conjunction with commercially available PCI-PCI bridge chips, can expand the cPCI bus in 8 slot increments. In this manner a CompactPCI system with 16, 24 or even 32 slots can be fabricated. 3U cPCI processor, (controller), boards use two connector modules which have predetermined I/O terminations designated for the combined 220 contact positions which are used for power, ground, and 32 bit or 64 bit PCI signals. This format uses two connector modules, a lower module called *J1* which has 110 signal contacts with a Keying Area and an upper module called *J2 which also* has 110 signal contacts. PICMG has reserved twenty contact positions for future use and has not specified I/O termination mapping for these contacts at this time.

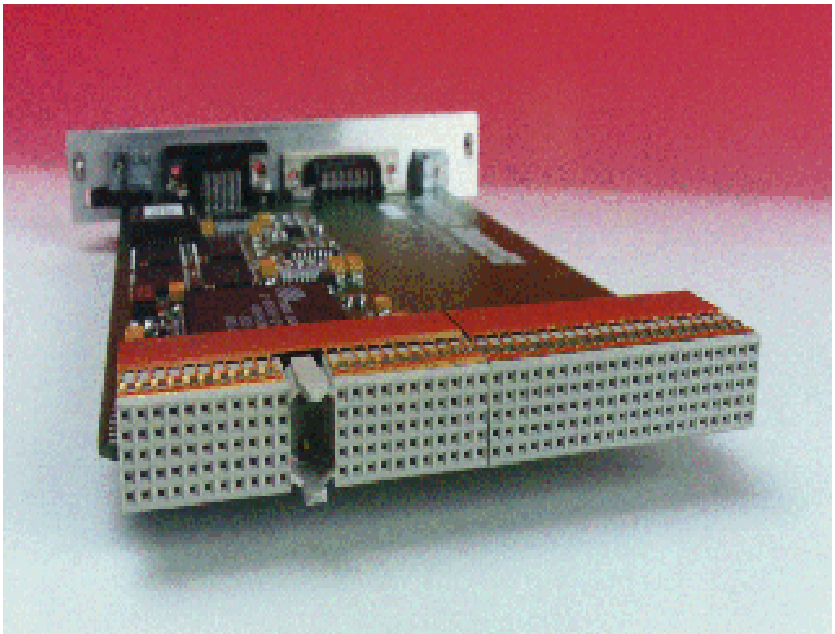

Photo: 3U cPCI Printed Circuit Board

Backplanes use male (pin) connectors and printed circuit boards use female (socket) connectors. Printed Circuit Boards that only perform 32 bit functions can use a single 110 position *J1* connector.

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As shown in Figure 1, five connectors are used in a typical 6U application. In accordance with the cPCI standard, *J1* is always used to provide the 32-bit PCI bus interface function for both the 3U and 6U versions. The *J2* connector can be used as an additional 32 bit bus interface, and when utilized in this manner, doubles the bus width to 64 bits. On 6U PCB's, connectors *J3*, *J4*, and *J5* provide an additional 315 I/O positions which are applied to "user defined" signal distributions. As one can see from these combinations, *J1* and *J2* represent the *cPCI bus* and *J3*, *J4*, and *J5* provide the structure for the *local bus*. The Enterprise Computer Telephony Forum, ECTF, has defined the *local bus* even further by developing software and hardware bus interfaces named *H.100* and *H.110* respectively. By accessing the H.110 interface through the *J4* connector, all PCB's plugged into the cPCI bus are capable of bi-directional data transfers with all other PCB's in the system. Additionally, the CompactPCI standard recognizes the use of mezzanine cards plugged into the PCB's, allowing them to support advanced telephony applications.

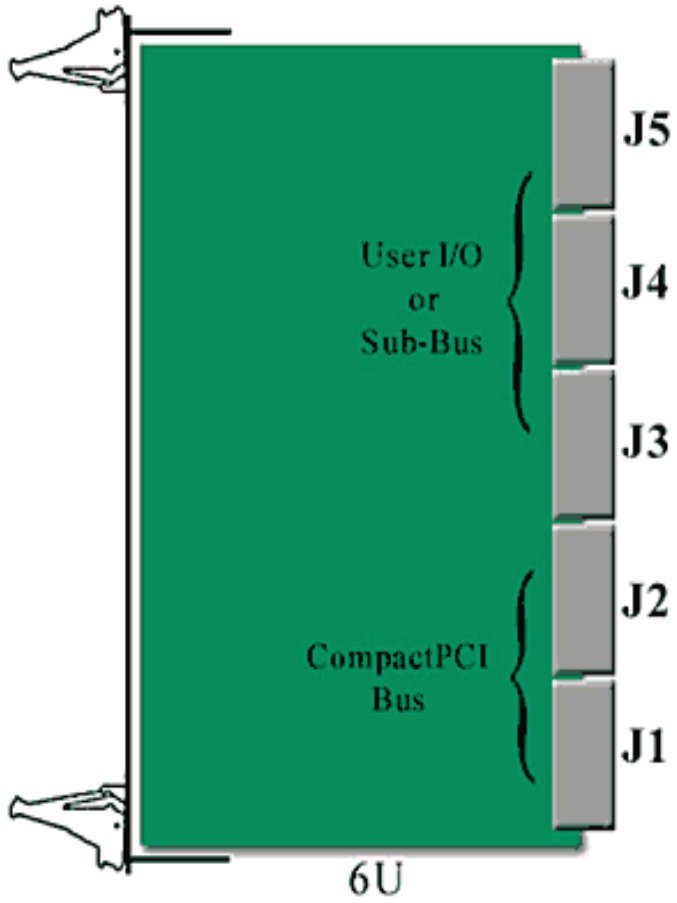

Figure 1

Although cPCI configuration is limited to a cluster of 8 cards, (1 CPU and 7 expansion), its' scalable potential was recognized by the ECTF and the Computer Telephony Specification, *PICMG 2.5*, was created to define how CompactPCI Systems should use the H.110 bus. For example, by using *cluster bridges*, it is possible to combine multiple cPCI clusters in a single chassis. As compared to ISA bus, this scaling technique offers a, (theoretical), 10:1 improvement in tier 1 terminations per system.

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As mentioned earlier, a second PCB, (transition card), may be plugged into the rear of a vertically orientated cPCI backplane. This dedicates all processor activity to the front-panel PCB, allowing all cabling associated with a particular card to be plugged into an electrical interface at the rear of the system. By having two separate sections, front PCB's can be unplugged without disturbing the cabling secured to the transition card. As shown in Figure 2, the *J5* connector is the conduit for all I/O transfers between a particular rear or front combination. Here again, interoperability has been assured by the issuance of the IEEE 1101.11 specification which defines the requirements for rear transition cards used on cPCI bus backplanes.

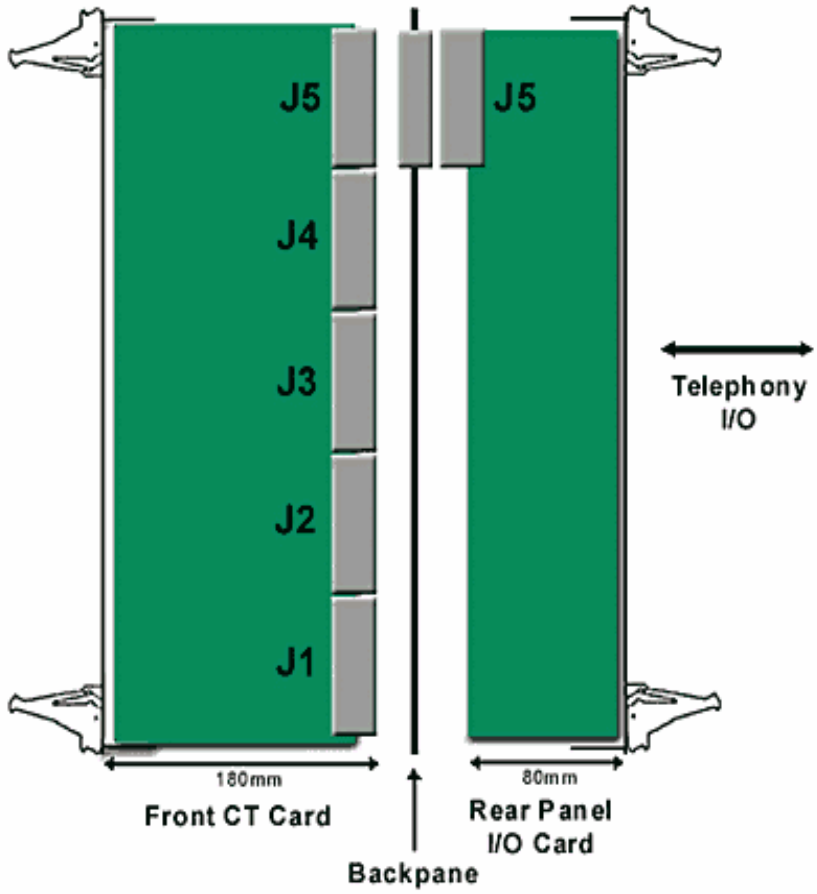

Figure 2

Perhaps one of the more critical factors to cPCI's adoption for telephony applications has been its' proven ability to provide true *hot-swappability*.

Hot swappability or live insertion is defined as the ability to insert or remove a printed circuit card from a live system. The insertion or removal of any card must not cause any system disruptions. *PICMG 2.1*, the Hot Swap standard, was released in July of 1998 and contains specific requirements for this procedure which involve hardware and software processes that are linked to electrical signals. In general, hot swapping is dependent on two key factors. First, to maintain synchronization, the PCI bus silicon chips must communicate directly with each other, and second, the backplane pin connectors must offer 3 variations of mating length in order to provide a *first make-last break*, (FMLB), connector engagement sequence. The FMLB contact arrangement provides a predictable pecking order of signal distributions which might best be categorized as Ground - Signal - Signal terminations.

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No discussion of Computer Telephony Integration would be complete without addressing software. The CompactPCI backplane provides a seamless connection to all peripherals attached to it. This allows the CPU card to become a common resource to the system. CompactPCI also supports many different operating systems without modification, including those that operate on PC's. This gives developers the freedom to select CPU's based on the application and makes it possible to run desktop software on cPCI systems. Also, there is a wide variety of PC peripherals which are cPCI compliant that can be integrated into a CompactPCI platform.

Given the flexibility of the CompactPCI platform, the following summarizes the applications to which it can be applied:

- PC based systems built around various kinds of network interfaces are common today:
  - Tier 1, asynchronous transfer mode (ATM), and Internet Protocol (IP),
    - Despite their economy and reliability, these systems have not always been adopted by industry
    - PC solutions have answered many of the arguments against them, but objections will still be raised.
- CompactPCI changes all of this:
  - Delivers cost effective complex systems,
  - Developers can provide cost effective functionality and telco grade reliability.

Computer Telephony Integrators can now provide telco grade equipment using technologies that have evolved from the PC world. Robust, high density, fault-tolerant, and reliable applications, (comparable to VME Systems), can be readily deployed. CompactPCI will be implemented in networks throughout the telecommunications industry, and as more and more networks are rolled out by more and more operators, cost considerations will surely force purchasers in the direction of systems designed using this new technology. For those manufacturers involved in manufacturing the connectors, cable assemblies, and backplanes which will inevitably support the proliferation of this technology; this trend translates into… *more-of-everything…*!!!

