PC/104 evolves meeting the embedded military market needs

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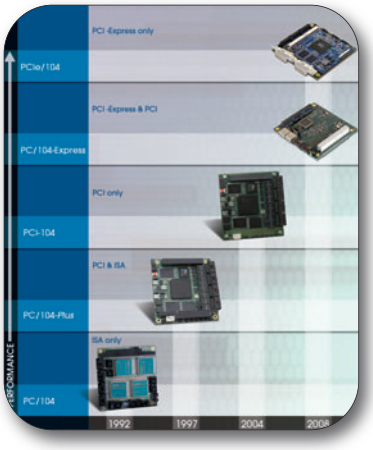
This article describes the evolution of the PC/104 form factor and its advantages in applications which require high performance, low power and small form factor.



The PC/104 form factor has allowed both embedded and laboratory system designers to keep development costs low through the use of commercial off-the-shelf (COTS) products. The PC/104 specification was formally introduced in 1992. The initial specification used the ISA bus for this card format. The ISA bus of the original IBM PC, as established by the IEEE P996 specification, is still fully supported today by PC/104 technology almost two decades after it was created. The form factor is a small and compact design that is well suited for small embedded applications and rapid prototyping in the lab. The card is only 3.575 inches x 3.775 inches (90 mm x 96 mm) and uses a stacking concept where one card sits on top of the other and allows you to build a tower of cards. The pins from one card insert into the card below it to provide the ISA bus interface. When stacked, the card spacing is 0.6 inches. The I/O connection to the card is usually provided at the card edge and allows system manufacturers to route the internal cable to rugged connectors at the edge of the box as they see fit. This stackable multi-board system form factor provides a shock and vibration resistant off-the-shelf computing solution for many interfaces. DDC provides cards for MIL-STD-1553/1760, Enhanced Bit Rate 1553, ARINC 429, and Synchro/Resolver with many cards combining several different types of I/O on one board to save power, space, weight and cost. This stacking concept allows system designers to eliminate backplanes that consist of large metal card cages, making the overall format smaller in size and lower in cost. This proved to be an ideal format for military platforms such as tanks, jet fighters, UAVs, and other platforms that require a small form factor. Applications such as displays, data recorders, data loaders/verifiers, small situational awareness systems, or mission computers are an ideal fit for the PC/104 format. Many systems have moved towards this type of architecture including the Common Munitions BIT/Reprogramming Equipment (CMBRE). This system is used to initiate built-in-test (BIT), provide BIT status, and upload/download and verify applicable software, including mission planning for smart weapons. CMBRE is designed for operation in harsh environments, and uses DDC PC/104 card that contains EBR-1553 and MIL-STD-1553 all on one card. The BU-65580/81C series of PC/104 cards provide a complete COTS solution for interfacing between an embedded PC/104 bus and one to four Enhanced Bit Rate - 1553 Channels while also providing an optional MIL-STD-1553 dual redundant interface. Enhanced Bit Rate - 1553 (EBR-1553) is a 10Mbps data bus protocol based on the familiar MIL-STD-1553. The two addressing modes of the card serve to provide compatibility with both Intel and Motorola processor platforms. Providing both MIL-STD-1553 and EBR-1553 on one board allows system designers to bridge

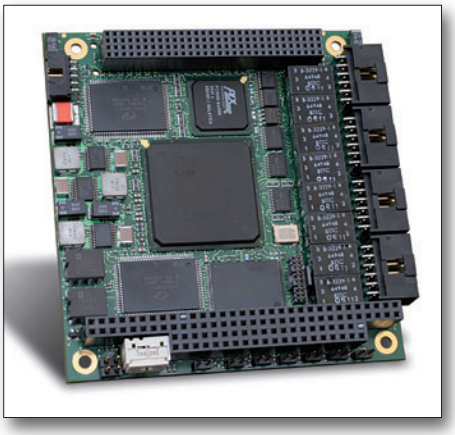


Figure 1. DDC MIL-STD-1553 PC/104-Plus card

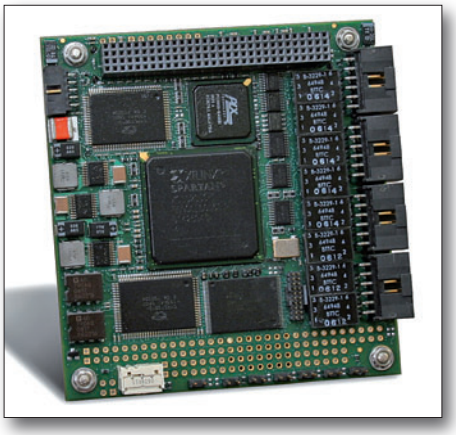


Figure 2. DDC MIL-STD-1553 PCI-104 card

between MIL-STD-1553/1760 weapon system interfaces and the newer, higher speed, EBR-1553 interface. The PC/104 format kept evolving over time to fulfill changing needs. The PCI bus was introduced to the card format in 1997. This version was developed by Ampro Computers and offered to the PC/104 consortium in September 1996. The consortium finalized the specification, and PC/104-Plus was subsequently approved by the Consortium voting members in February 1997. PCI has the advantage of higher data rates and larger memory space, when compared to ISA, along with Plug and Play resource allocation.

The Plug and Play aspects of the PCI bus allow for easier integration with multiple cards in one stack. Just as the DDC combination of MIL-STD-1553/1760 and the newer EBR-1553 interface on one card helped bridge the gap between older and newer weapon interfaces, the initial PC/104-Plus format had both ISA and PCI connections on one card to help ease the transition from ISA to PCI. The PC/104-Plus specification defines that the card shall contain both ISA and PCI connectors on it. The ISA connector on the PC/104-Plus I/O cards is a pass-through connector while the PCI connector is active. The main CPU card would contain both ISA and PCI so that you could mix and match older PC/104 cards that used only ISA bus and newer PC/104-Plus cards that use the PCI interface all on one stack. The mounting location and size of the card did not change, so as to allow for a very smooth transition from ISA to PCI.

Since you could build a system using PC/104-Plus that had older PC/104 cards that used the ISA bus and newer PC/104-Plus cards that used the PCI bus, the new format gained popularity very quickly. As it did so, the PCI-104 specification was finalized in November 2003. This format eliminates the pass-through ISA connector that existed on the PC/104-Plus card. This now allowed cards to be stacked with only the PCI bus interface. By this time many commercial off-the-shelf PCI-104 cards were being developed so that you could build a PCI-only system.

PCI/104 also provides a unique advantage for cooling PCI/104 systems. Although the PC/104 specifications do not specify conduction cooling, many embedded military applications use a custom plate to conduction cool the boards in a stack. In general, a heat sink on the individual I/O board is not designed into boards that are to be used in conduction-cooled stacks, as it may interfere with the cooling method that the system designer chooses. PCI/104 boards allow manufacturers another free side of the board to pass a thermal heat plate through between cards on a stack. The thermal heat plate would then make contact with the hot components of the card and conductively cool the heat out to the sides of the enclosure to help remove the heat from the inside of the stack. In PC/104-Plus the ISA connector may have been in the way of this type of thermal cooling design. DDC keeps one side of PC/104-Plus or two sides of PCI/104 cards free to allow entry for a custom plate that can be used to conduction-cool boards in a stack. Low power is very critical due to heat building up in the stackable nature of these systems. This makes it very important for individual boards to be able to process their own data and offload the host processor as much as possible. For example, DDC 1553 cards have a DMA engine that can be used to offload the processing of 1553 data from the card to the host. This allows the host CPU to spend fewer cycles processing 1553 data and run cooler. The introduction of new processors that have capability for relatively high processing bandwidth with low power requirements should be a very reason for the PC/104 form factors to grow even more in popularity within the embedded military community. Leading CPU manufacturers such as Advanced Digital Logic, Parvus, Ampro, Kontron, and many others already have products that are very low power.

Power supplies are cards that are stackable in the system much like any other I/O card. The stack options include PC/104, PC/104-Plus, and PCI/104 power supplies in many different power ratings. An external supply can be a small power brick that provides +5V to a CPU or it can be a small stack, or may utilize the supply in a larger system hosting the PC/104 system. Although the PC/104-Plus specifications allow for +5V, +12V and -12V in the system, many modern systems provide only +5V power to the system in order to provide a more efficient low power environment. The newest PC/104-Plus and PCI-104 cards from DDC that contain ARINC 429, MIL-STD-1553 and Multi-I/O 1553/429 on one board can be powered off of only +5V.

The PC/104 form factor continues to evolve with the introduction of PCI/104-Express in 2008 to add PCI-Express (PCI-e) functionality. The PC/104 Consortium chose PCI Express because of its full PC market adoption, performance, scalability, and growing silicon availability worldwide. It provides a new high-performance physical interface while retaining software compatibility with existing PCI infrastructure. Much as PC/104 has done in the past, the PC/104-Express form factor contains PCI and PCI-e on board in order to bridge the gap and allows system designers to mix and match PCI-based boards and PCI-e based boards all in one stack. ■