EPIC Express: A Bridge to the Future for High-Performance I/O

EPIC Express combines the performance advantages of PCI Express with the widely used PC/104 bus in a small, stackable format. The result is one of the broadest ranges of stackable, plug-on I/O available, as well as a clear migration path to future, high-performance embedded applications.

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A technical evolution is propelling PCI Express to become the wave of the future for high-performance I/O in industrial/embedded applications. PCI Express provides a high-speed, high-performance, point-to-point link for interconnecting devices: data is transmitted on one set of signals and received on another set of signals. It therefore offers relief for data bottlenecks created by attempts to process an increasing amount of data in real time.

The new EPIC Express standard harnesses the performance advantage of PCI Express by defining a small, stackable format with high-performance connectors for the PCI Express interface. EPIC Express also incorporates the popular PC/104 I/O connectors. This gives designers access to one of the broadest ranges of "plug-on" or stackable industrial I/O available in the marketplace today.

Additionally, PCI Express bandwidth can be scaled upward to keep pace with the increasingly faster CPUs that will be developed in the next 10 years. The combination of these two buses on a single platform therefore makes the compact, rugged EPIC Express standard an ideal platform for today's and tomorrow's embedded systems. This is the kind of stable platform that is attractive to embedded system designers.

This is the exciting part of EPIC Express: it provides embedded system designers a clear roadmap for upgrading and migrating their systems toward the faster serial interfaces of the future, while allowing them to implement this migration at their own pace and in their own fashion. With PC/104 and PCI Express on one platform (Figure 1), system designers can map their applications' initial design and

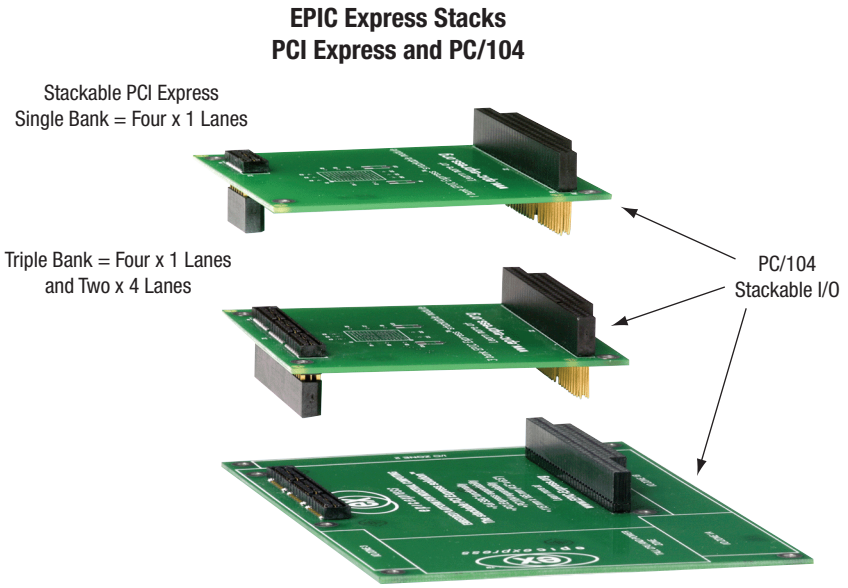

Figure 1 The new EPIC Express standard incorporates the performance advantage of PCI Express connectors as well as PC/104 I/O connectors in a small, stackable format. Including PC/104 and PCI Express on one platform gives a clean migration path for hardware and software.

Figure 2 The AVATAR model remote control helicopter developed by USC's Autonomous Flying Vehicle Team utilizes a PC/104 stack for vision and another for flight control. It is capable of fully autonomous flight and includes flight-avoidance capabilities.

future upgrades by taking into account the future impact of emerging technologies. This makes a clean migration path from the standpoint of both hardware and software. It is also a key benefit of the EPIC Express specification: it provides a bridge to the future.

Adaptability, Scalability, Flexibility

EPIC Express places the two basic modes of communication—parallel and serial—onto one format. The PC/104 bus provides parallel communication as a simple I/O channel suited to industrial and control types of I/O, while PCI Express provides the high-bandwidth serial interface that moves data at Gbit/s rates suited to fast communication of large amounts of data. The combination of these two technologies on one format gives embedded system designers the ability to maximize their designs to fit specific size, power, environment or cost constraints.

Under the new EPIC Express standard, two configuration options are available for implementing PCI Express: Standard and Full. The Standard option supports four x1 lanes using a single 28-pin connector. The Full option supports four x1 lanes and two x4 lanes for future, higher bandwidth applications, as well as additional DC power.

With the Standard configuration, designers of applications that are cost-sensitive or have lower bandwidth requirements can implement PCI Express with a single-bank connector with four x1 links in a very small, cost-effective space. This is ideal for applications that need to take advantage of Gigabit Ethernet.

The Full configuration, with four x1 links and two x4 links, provides higher bandwidth, requires the full three-bank connector and has more power. This ensures that high-power, bandwidth-hungry devices, such as disk controllers and multi-gigabit communications devices, will perform at maximum throughput.

For now, EPIC Express does not implement x8 or x16 links. The exclusion of x8 reflects some current industry thinking that x8 PCI Express devices will be rare. However, the need is already apparent for a x16 definition to allow EPIC Express to take advantage of the full range of video cards in the future.

As a bridge standard, PC/104 is an extremely important part of the EPIC Express standard. It will probably be needed in most applications for some time to come. As the market matures, the convenience of a stable PCI Express standard will attract users of its own. How this will affect PC/104 on EPIC Express will depend on the success of the solo adoption of PCI Express, and on the market forces affecting production of the silicon required to implement PC/104.

Support for Current PC/104 I/O and Expandable PCI Express Bandwidth

In the case of embedded systems that use the PC/104 bus for both an I/O control channel and a sophisticated user interface, continual improvements in video and communications can keep the system in an almost continuous state of re-design.

One example of this can be found in a project conducted by the University of Southern California's Autonomous Flying Vehicle Team. For several years, the students have been working on a model remote control helicopter that utilizes two PC/104 stacks: one for vision and the second for flight control. Named AVATAR (Figure 2), the helicopter is capable of fully autonomous flight and has recently been upgraded to include flight-avoidance capabilities.

AVATAR flies without human intervention and performs GPS waypoint navigation, autonomous vision-based landing and autonomous sensor-based takeoff. PC/104 technology has given the team a lightweight, low-power and high-performance system through two PC/104 stacks. One is a control stack that includes serial ports, timer/counters, sensor control and digital I/O. The other is a vision stack that captures images from three cameras.

As the USC Autonomous Flying Vehicle Team researches new capabilities—such as autonomous landing on a moving target, deployment on a moving target, stealthy target pursuit and vision-based obstacle avoidance in 3D—EPIC Express presents an exciting system platform for implementation of their goals. It can add high-bandwidth serial communication for camera systems and video requirements, which will allow AVATAR to perform even more complicated tasks.

A different type of application that can take advantage of EPIC Express is automated cleaning equipment for the metallurgy industry. The cleaning process is highly automated, but recently enacted industry quality standards now require documented microscopic snapshots verifying levels of cleanliness.

During the existing cleaning process, the cleaning solution is monitored for temperature, levels of contamination and time. These traditional electronic control processes are imple-

mented with stacking PC/104 I/O boards. The sampling rates and time responses required for switching these controls are well suited to a parallel bus such as PC/104. However, upgrading the system with a video frame grabber to visually document the cleaning might be better implemented through a serial PCI Express expansion.

EPIC Express easily enables this mixing and matching of PC/104 and PCI Express technology, which helps system designers maximize their system's performance based on the type of interfaces they need. Selection of the I/O platform is often determined by the general characteristics of the I/O type and its suitability for a particular embedded system. Selection criteria make some choices clear cut, while others are less obvious and require more system-level engineering (Table 1).

Typical Embedded System I/O Checklist		EPIC Express Platform	
I/O Type	Selection Criteria	High Performance PCI Express	Standard PC/104
x86 processor	• Speed • Math coprocessor • Extended Temperature	✓	
Serial ports	• Type (16450 or 16550) • Levels (RS-232 or RS-422/ RS-485)		✓
Printer ports	• Will it be used for a printer? • Will it be used for digital I/O?		✓
Ethernet connection	• Speed: 10/100/1000	✓	✓
Video	• Display type – CRT, Flat Panel: LCD or TFT • Resolution	✓	✓
Serial Buses	• USB Type 1 or 2 • PCI Express • SATA	✓	
Operating Systems	• Windows Based • Linux • RTOS	✓	
Digital I/O	• Voltage level • Current source and sink capability • Initialization state		✓
Analog I/O	• Resolution • Range • Input type (single-ended or differential) • Conversion time • Method of starting conversions (hardware or software)		✓
Solid-state disks	• Type – Compact Flash, USB, DiskOnChip • Capacity • Physical size • Removability		✓

Table 1 EPIC Express's combination of PC/104 and PCI Express technology in the same platform helps designers maximize system performance based on the type of interfaces they need.

The Future of PC/104 and PCI Express

In the future, the data acquisition industry will be making advances in faster and higher-performance data gathering technology. As a stackable I/O channel, EPIC Express is an ideal platform for implementing this technology. In addition to its stackability, faster performance and compact size, EPIC Express offers system-level features made available by PCI Express. For industrial applications, these features include a software level to implement improved error detection, enhanced reliability, power management, hot-plug and free-flowing data. These higher-level system features will be required in the industrial controls of tomorrow to ensure the quality demanded in high-precision manufacturing environments.

EPIC Express brings greatly enhanced capabilities to system designers and is well matched to the demanding control requirements that emerging technologies will present during the next decade. Designers of control systems will seek to incorporate the technology being gained from military research and development into new tools for intelligence gathering equipment and weapon identification applications. Recent government funding for research and development in the emerging area of nanometer-scale technology will also result in the need for new manufacturing technologies and embedded control systems to implement emerging processes. The technologies being developed in these areas are finding their way into high-speed manufacturing lines, security applications, medical devices and automation processes.

In the pharmaceutical and chemical industries, designers are pursuing technologies to use in high-precision manufacturing processes for advanced drug delivery systems, including implantable devices, in the next few years. In medical applications, diagnostic tools such as cancer-tagging mechanisms and real-time diagnostics for physicians will need these enhanced control and monitoring capabilities.

In the field of wear-resistant coatings, the Department of Defense recently supported partnerships among the Navy, academia and industry to develop processes suitable for manufacturing more durable coatings for use in the marine environment. The result has been a nanoscale coating for use on air valves that will result in a $20 million reduction in maintenance costs over 10 years. The processes for manufacturing these coatings have required sophisticated embedded systems with control capabilities and user interfaces.

These advancements, as well as those not yet dreamed of, come with associated challenging system design issues and typical tradeoffs among heat, power, performance, size, design ruggedness and cost. This creates a future in high-performance embedded applications that is ripe for the EPIC Express format. ◢

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