

*Introducing*  
**PXI Express:**

*Increasing  
bandwidth  
and  
preserving  
backward  
compatibility*

By Greg S. Caesar

*In its seventh year, PXI, by many measures, has become the most successful industry-standard platform for measurement and automation. Not only was PXI able to grow rapidly during one of the industry's worst downturns, but PXI adoption also continued to gain momentum and even exceeded analyst forecasts with over 40 percent growth in 2004. Commercial standards have contributed to the extraordinary PXI adoption rate in applications ranging from test to control, and the future evolution of PXI based on PCI Express technology will expand the platform to serve more applications while maintaining backward compatibility.*

In May 2005, the PXI Systems Alliance (PXISA) began work on the PXI Express specification with a passage deadline set for the fourth quarter of 2005. PXI Express brings PCI Express signaling performance to PXI. That signaling performance expands PXI backplane capabilities from 132 MBps to 6 GBps which in turn opens up new applications for high performance instrumentation and data acquisition. Similar to the PXI standard today, existing industry standards will leverage PXI Express to benefit from high component availability at lower costs. PXI Express also maintains software compatibility with industry standard technology, so customers can use the same software tools and environments with which they are familiar. Not only does PXI Express provide a giant leap in measurement and automation performance, but it also delivers a high level of compatibility with PXI. This means customers can preserve their existing PXI hardware and software investments as they embrace future PXI Express systems.

### **Current and new applications**

Three main market segments have broadly adopted PXI systems:

- Test and measurement
- Real-time control and simulation
- Industrial data acquisition

In all areas, PXI has seen tremendous industry expansion, with vendors investing heavily in new PXI product introductions. For example, since 2003, PXI vendors have released, on average, more than one new PXI product per week. Each new product expands PXI platform capability, bringing PXI into new areas of performance and lowering the PXI system cost to enable broader industry adoption.

The increased PXI backplane bandwidth (from 132 MBps to 6 GBps) fueled by PXI Express represents a more than 45x improvement in bandwidth while maintaining software and hardware compatibility with PXI modules. This new performance is expected to extend PXI into new application areas, many of which incorporate only proprietary and extremely expensive instrumentation systems. Instrument boards based on PCI Express will deliver drastically more throughput than boards today, as well as feature lower costs by not requiring cost additive features such as deep onboard memory. For example, a digitizer based on PCI Express will have a 1 GBps direct path to the CPU module (either embedded or MXI to a PC), that is approximately 8x the throughput of 32-bit, 33 MHz PCI today. To translate this into real measurement terms, a high resolution 16-bit IF digitizer or generator could potentially stream up to 500 MHz bandwidth continuously to the CPU without bus limits or sharing bandwidth with adjacent modules.

However, many existing PXI applications do not benefit from new PXI Express performance. Specifically, classical functional and automated test systems based on hardware such as digital multimeters (DMMs), switches, multifunction data acquisition, and low-frequency (<10 MHz) generators and analyzers fit well within current PXI performance. For these reasons, one of the most powerful aspects of the PXI Express specification is the compatibility and coexistence with current PXI technology. Because many existing applications do not benefit from PCI Express technology, the new specification does not force redesign of current modules. It instead provides for backward

“  
...one of the most  
powerful aspects of the  
PXI Express specification  
is the compatibility and  
coexistence with current  
PXI technology.”

compatibility. Therefore, integrators benefit from the best of both worlds when selecting a future PXI Express platform; new slots with extremely high, dedicated bandwidth, plus compatibility with the installed base of existing PXI products.

### PCI Express impact on the mainstream PC market

The PCI Express specification was passed in 2002, and PCI Express slots began appearing in mainstream PCs in 2004. Industry-leading companies such as Intel, Dell, Microsoft, and HP are driving PCI Express technology in desktop PCs, servers, and workstations. PCI Express, which transfers data serially, was created to address the bandwidth versus slot-count trade offs of the parallel PCI bus that provides 132 MBps in the most typical implementations. Data is sent in packets through pairs of transmit-and-receive signals, called lanes, with a 250 MBps bandwidth in each direction. Multiple lanes are typically grouped together into x1 (*by one*), x4, x8, or x16 lane widths, creating a bus capable of transferring data up to 4 GBps per direction in the x16 implementation. In addition to providing dedicated bandwidth per direction, PCI

Express delivers independent bandwidth per slot. For example, a server-class PC with four x4 PCI Express slots can provide 1 GBps per direction bandwidth to each of the four slots simultaneously, for a total of 4 GBps among the four slots. By comparison, a typical 33 MHz, 32-bit PCI bus shares 132 MBps bandwidth among all slots, which results in bandwidth trade-offs in multiboard systems.

The need for high-performance graphics cards drove the initial PC adoption of PCI Express during the first half of 2004. Today, one x16 PCI Express slot in Dell Dimension desktop computers replaces the older Advanced Graphics Port. In addition, these desktop computers also have a single x1 PCI Express peripheral slot, as well as three 32-bit, 33 MHz PCI slots. The availability of side-by-side PCI and PCI Express slots is a trend expected to continue for years to come. For example, Intel's roadmap ([www.intel.com/public/roadmap](http://www.intel.com/public/roadmap)) shows that Intel is including PCI and PCI Express I/O in upcoming chipsets. While desktop PCs incorporate x1 PCI Express peripheral slots, servers and workstations include the higher bandwidth x4 and x8 slots.

The PCI Express software architecture is backward compatible with PCI, so both end users and board manufacturers can preserve existing investments in driver and application software if they migrate to a PCI Express based system. Given the size of the PCI market today, this software compatibility is a major factor driving new PCI Express adoption. Estimates say more than half a billion PCI slots will be shipped in 2005.

### PCI Express integration into PXI

The PCI Industrial Computer Manufacturers Group (PICMG) and PXISA are executing coordinated plans to integrate the performance of PCI Express into both CompactPCI and PXI, while preserving backward compatibility. Because PXI is based on CompactPCI, work on CompactPCI Express, including efforts to preserve PXI module compatibility, began first in early 2004. The CompactPCI Express specification defines the fundamental mechanical and electrical features of CompactPCI Express systems, and therefore PXI Express systems. This includes:

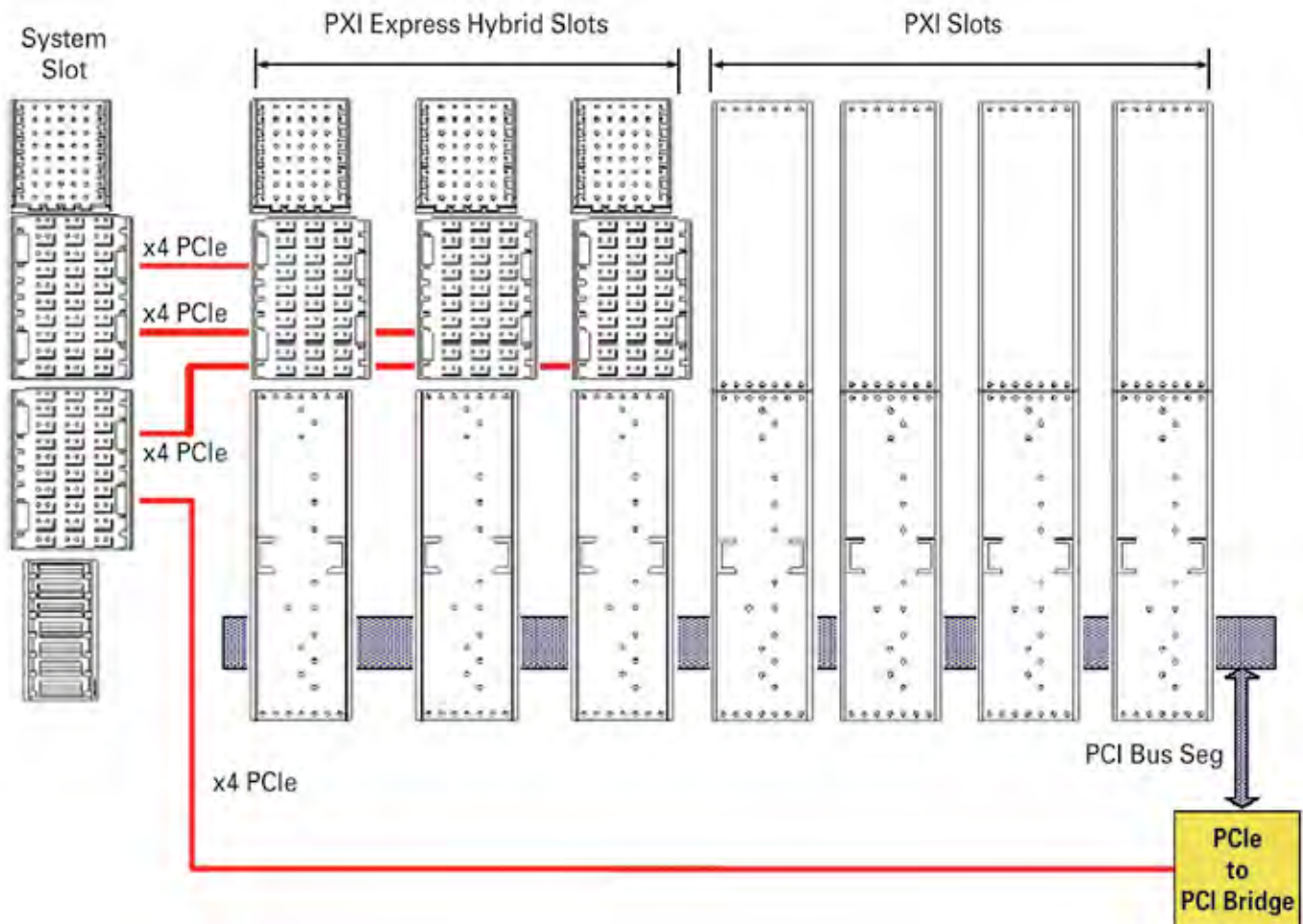


Figure 1

- The selection of connectors to support PCI Express
- Definitions of slots and board mechanicals
- Definitions of slot/board electrical signals
- Compliance-testing requirements.

The CompactPCI Express specification has completed the technical phase, and final passage of the specification is expected this summer.

With the CompactPCI Express specification locked down, PXISA launched work on the PXI Express specification in May 2005, with targeted passage in the fourth quarter of 2006. PXI Express incorporates CompactPCI Express technology with additions for PXI compatibility, timing and synchronization, and system software frameworks.

**PXI Express basic hardware features and software compatibility**

Figure 1 shows the basic layout of a PXI Express backplane. This eight-slot backplane adds three new high-performance slots (1 GBps dedicated bandwidth each), while preserving compatibility with existing PXI modules throughout all slots. PCI Express electrical lanes are routed from the system controller (either an embedded controller or MXI link) to the slots, providing a high-bandwidth path from the controller to the backplane slots. In addition, the installation of an inexpensive PCI Express-to-PCI bridge on backplanes provides PCI signaling to all PXI and PXI Express hybrid slots. This ensures compatibility with the installed base of PXI modules on the backplane. The system controller slot is capable of supporting up to a x16 plus a x8 link, providing a total of 6 GBps bandwidth to the PXI backplane.

At the center of the new features is a hybrid peripheral slot, which delivers support for both PCI and PCI Express signaling by taking advantage of available pins on the high density backplanes. This creates a level of backward compatibility not available in desktop PC card edge connectors. In this hybrid peripheral slot, users can install modules that use current PCI signaling, as well as new high performance PXI Express modules.

As shown in Figure 2, the compatibility of the hybrid slot is made possible by retaining today's PCI signaling and PXI timing and synchronization signals in the P1 and XJ4 connectors, respectively. In addition, the new XJ3 connector provides connectivity for x8 PCI Express, as well as pins for additional timing and synchronization. This detail of the new PXI Express hybrid peripheral slot demonstrates PXI Express hardware compatibility. Unlike slots in desktop PCs, the extra area for pins on the backplane allow installation of modules with either PCI or PCI Express in a single slot.

PCI Express uses the same driver and operating system model as PCI, which ensures complete software compatibility among PCI based systems (for example, PXI) and PCI Express based systems. Neither vendors nor customers need to revise driver software or application software for backward compatibility.

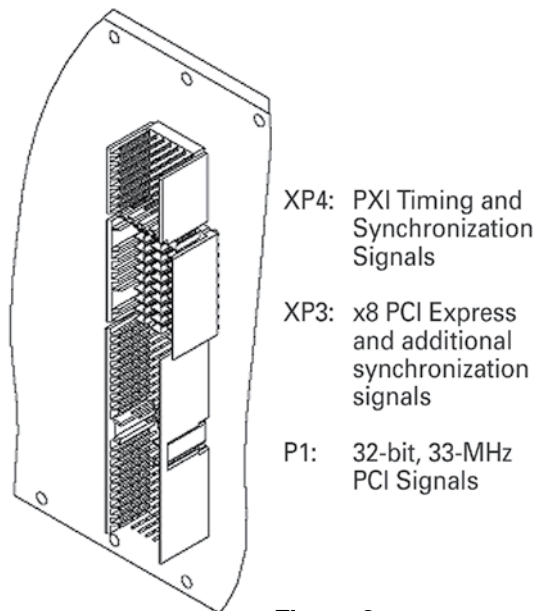


Figure 2

**The future of PXI and PXI Express**

The final PXI Express specification is expected to pass in late 2005. In 2006, users can expect to see the first PXI Express chassis, controllers, and modules enter the market, providing a platform for new applications requiring levels of performance not available today. However, because PXI Express retains

“...both end users and board manufacturers can preserve existing investments in driver and application software if they migrate to a PCI Express based system.”

compatibility with PXI, vendors continue to aggressively invest in PXI products, fueling an average release of more than one new PXI product per week since 2003. Additionally, vendors most likely will not invest in porting existing products that do not require additional bandwidth to the new PCI Express signaling type because they retain compatibility and do not gain any new performance benefits.

This is truly an exciting time in the PXI marketplace, as PXI Express is poised to deliver a massive boost in performance to the platform without incurring a compatibility cost. Both vendors and users will benefit from preservation of investments in current hardware and software, while retaining the option of adopting new, higher performance backplane systems as early as 2006.

*Greg Caesar is the PXI Platform Marketing Group Manager for National Instruments, as well as the marketing chair of the PXI Systems Alliance, a group of over 68 member companies dedicated to promoting the PXI standard and maintaining interoperability. Greg began with National Instruments in 2000, and he holds a B.S. in Chemical Engineering from Virginia Tech.*



**National Instruments**  
 11500 N. Mopac Expressway • Austin, TX 78759  
 Tel: 888-280-7645 • Fax: 512-683-8411  
 E-mail: greg.caesar@ni.com  
 Website: www.ni.com