PXI EXPRESS SPECIFICATION TUTORIAL

Introduction

The PXI industry standard has quickly gained adoption and grown in prevalence in test, measurement, and control systems since its release in 1998. PXI is being selected as the platform of choice for thousands of applications, from areas such as military and aerospace, consumer electronics, and communications, to process control and industrial automation. One of the key elements driving the rapid adoption of PXI is its use of PCI in the communication backplane. Now, as the commercial PC industry drastically improves the available bus bandwidth by upgrading from PCI to PCI Express, PXI has the ability to meet even more application needs by integrating PCI Express into the PXI standard. To ensure the successful integration of PCI Express technology into PXI and CompactPCI backplanes, engineers within the PXI Systems Alliance (PXISA), which governs PXI, and the PCI Industrial Manufacturers Group (PICMG), which governs CompactPCI, have worked to ensure that PCI Express technology can be integrated into the backplane while still preserving compatibility with the large installed base of existing systems. With PXI Express, users will benefit from significantly increased bandwidth, guaranteed backward compatibility, and additional timing and synchronization features.

Meeting the Needs of New Applications

By taking advantage of PCI Express technology in the backplane, PXI Express increases the available PXI bandwidth from 132 MB/s to 6 GB/s for a more than 45X improvement while still maintaining software and hardware compatibility with PXI peripheral modules. With this enhanced performance, PXI can reach into numerous new application areas, many of which were previously served only by expensive, proprietary hardware. For example, the higher bandwidth available in PXI Express provides the military and aerospace industry new solutions for the following automated test applications:

- High frequency and resolution IF/RF acquisition and generation for communications systems test
- Digital acquisition and generation for testing high-speed serial protocols including proprietary LVDS-based protocols, Fibre Channel, IEEE 1394, and others
- High-channel-count data acquisition for structural and acoustical test
- High-speed image acquisition

Bringing PCI Express Technology to PXI and CompactPCI

PCI Express was introduced to improve upon the PCI bus. The most notable PCI Express advancement over PCI is its serial, point-to-point bus topology. Unlike PCI, which divides bandwidth between all devices on the bus, PCI Express provides each device with its own dedicated data pipeline. Data is sent serially in packets through pairs of transmit and receive signals called lanes, which offer 250 MB/s dedicated bandwidth per direction, per lane. Multiple lanes can be grouped together into x1 (pronounced “by-one”), x2, x4, x8, x12, x16, and x32 links to increase bandwidth to the slot. The dramatically improved data bandwidth minimizes the need for onboard memory and achieves faster data streaming. For instance, with a x16 link, users can achieve up to 4 GB/s of dedicated bandwidth per direction as opposed to the 132 MB/s shared across all devices of the 32-bit, 33 MHz PCI bus.

In order to successfully integrate PCI Express into PXI and CompactPCI and still maintain backward compatibility, the PXISA (www.pxisa.org) and the PICMG (www.picmg.org) executed coordinated plans to ensure a smooth transition. Because PXI is based on the CompactPCI specification, these efforts to integrate PCI Express first began with CompactPCI Express in early 2004. Defining the fundamental mechanical and electrical features of CompactPCI Express systems, the CompactPCI Express specification in turn defines the mechanical and electrical features of PXI Express systems. Released in June 2005, the CompactPCI Express (EXP.0) specification includes the selection of connectors for PCI Express, definitions of slot and module mechanicals, definitions of slot and module electrical signals, and compliance testing requirements. In May 2005, work on the PXI Express specification began, and in September 2005 the PXI Express specification passed. The PXI Express specification takes the CompactPCI Express technology and adds specifications for PXI compatibility, timing and synchronization, and system software frameworks.

Because the PXI Express backplane, an example of which is shown in Figure 1, integrates PCI Express while preserving compatibility with current PXI modules, users benefit from increased bandwidth and backward compatibility with existing systems. Hardware compatibility is provided by hybrid slots. Hybrid peripheral slots deliver signals for both PCI and PCI Express. With PCI Express electrical lines connecting the system controller slot to the hybrid and PXI Express slots, high-bandwidth data paths are available. Using an inexpensive PCI Express-to-PCI bridge, PXI Express provides PCI signaling to all hybrid and PXI peripheral slots to ensure compatibility with PXI modules. With the ability to offer up to both a x16 and x8 PCI Express link simultaneously, the system controller slot provides up to 6 GB/s of bandwidth to the PXI backplane, representing more than a 45X improvement in PXI backplane throughput. Individual hybrid and PXI Express peripheral slots, with a x8 PCI Express link, can provide up to 2 GB/s of dedicated bandwidth.

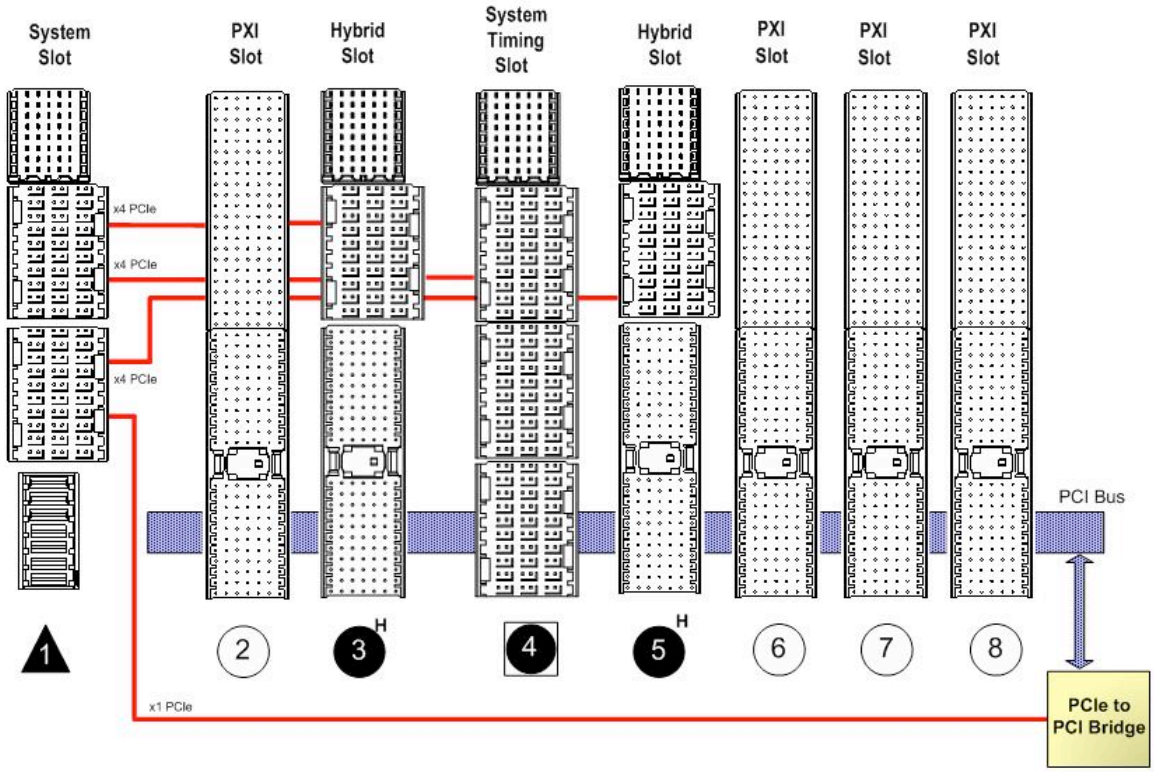

Figure 1. While preserving compatibility with PXI peripheral modules, this 8-slot backplane includes three high-bandwidth PXI Express peripheral slots.

By taking advantage of the available pins on the high-density PXI backplane, hybrid slots are capable of delivering signaling for both PCI and PCI Express. In so doing, hybrid slots provide backward compatibility not available with desktop PC card-edge connectors where a single slot cannot accept both PCI and PCI Express boards. With the hybrid slot, you can install a PXI module that uses PCI signaling or a PXI Express module that uses PCI Express signaling.

The three connectors of the hybrid slot are illustrated in Figure 2. The P1 and XP4 connectors provide PCI signaling and the PXI timing and synchronization signals of PXI. Using the new XP3 connector, the hybrid slot provides x8 PCI Express signaling as well as pins for additional timing and synchronization.

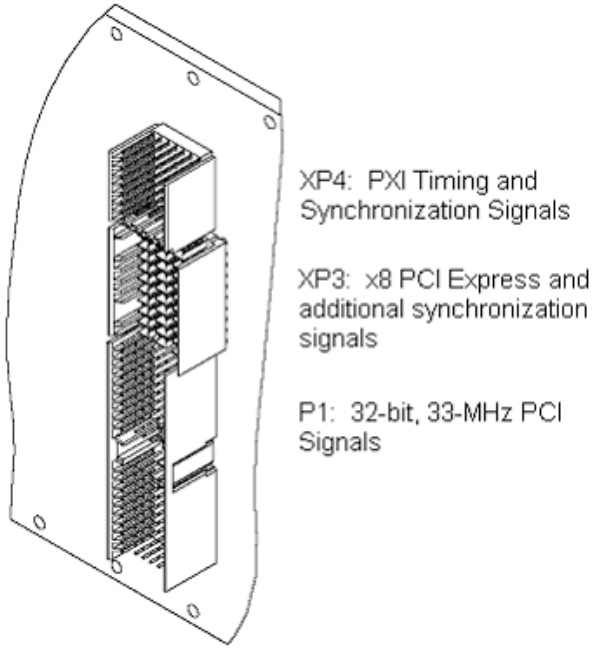

Figure 2. Unlike slots in desktop PCs, a hybrid slot accepts modules with either PCI or PCI Express signaling.

On May 12, 2005, the PXISA passed ECN-1 to the PXI Hardware Specification, which defines a modification to PXI peripheral modules that makes them compatible with hybrid slots in PXI Express chassis. Hybrid-slot-compatible PXI modules also work in past, current, and future PXI chassis. Traditionally, most PXI modules have had two large PXI connectors designated by the PXI Hardware Specification as J1 (32-bit, 33 MHz PCI bus) and J2 (power and timing and synchronization bus). The top connector, J2, has been replaced with a smaller connector, designated as XJ4, which retains the power and timing and synchronization bus. This modification is illustrated in Figure 3. In addition to PXI vendors implementing this change on current and future modules they produce, existing modules can be modified to be hybrid-slot-compatible.

Figure 3. Hybrid-slot-compatible PXI modules include the smaller XJ4 connector in place of the larger J2 connector.

Figure 4 demonstrates how the hybrid slot accommodates hybrid-slot-compatible PXI, PXI Express (and CompactPCI Express), and CompactPCI peripheral modules.

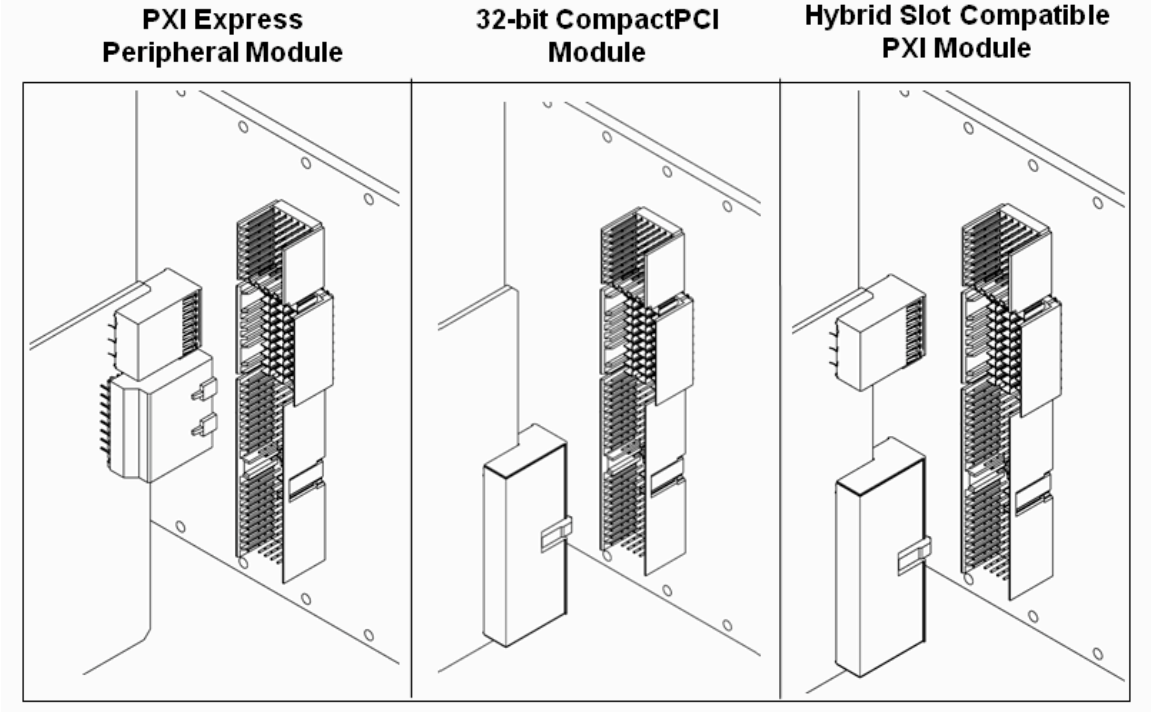

Figure 4. PXI Express, hybrid-slot-compatible PXI, CompactPCI Express, and CompactPCI peripheral modules can all be used in a hybrid slot.

Maintaining Software Compatibility

In addition to providing hardware compatibility through hybrid slots, PXI Express systems also provide software compatibility so that you can preserve your investment in existing software. PCI Express software compatibility is guaranteed through the PCI Special Interest Group (PCI-SIG), which includes companies such as Intel and Dell. Because PCI Express uses the same driver and OS model as PCI, the specification guarantees complete software compatibility among PCI-based systems, for example PXI, and PCI Express-based systems, such as PXI Express. As a result, both vendors and customers do not need to change driver or application software for PXI Express systems.

By maintaining software compatibility between PCI and PCI Express technology, the specification drastically reduces the cost for vendors and integrators to insert new PCI Express technology into existing test systems. With hardware compatibility, provided by the hybrid slot, and software compatibility, the cost of adding PXI Express technology is minimal.

Providing Additional Timing and Synchronization Features

PXI Express not only retains the timing and synchronization features of PXI, but also adds new capabilities by taking advantage of the technological advances that provide high-performance, low-cost differential signaling. Building upon the existing features of PXI, some of the additional timing and synchronization features provided by PXI Express include a differential system reference clock and differential star triggers, as shown in Figure 5. By using differential signaling, PXI Express systems benefit from increased noise immunity for synchronization signals and the ability to transmit higher frequency clocks. In addition to providing improved system accuracy and performance, high-frequency clocks interface well with modern processes and reduce module prices by removing the need for components such as clock multiplication circuits.

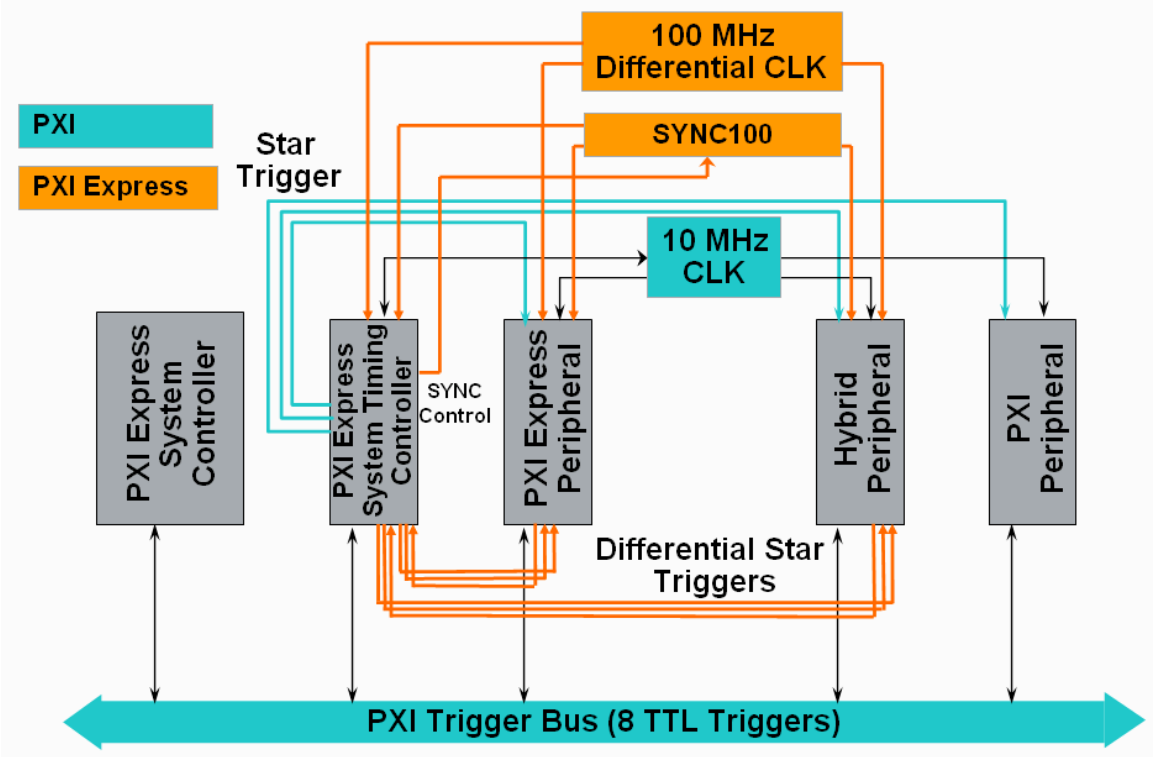

Figure 5. By building on the existing capabilities of the PXI platform, PXI Express provides additional timing and synchronization features to achieve better measurement accuracy and handle new applications.

The Future of PXI

PXI Express is a part of the PXI platform, and PXI vendors will continue to invest in that platform by developing products based on both PCI and PCI Express signaling. While the integration of PCI Express technology into PXI does allow PXI Express to reach new applications, many existing PXI applications will not benefit from the enhanced performance of PXI Express. For example, hardware such as digital multimeters (DMMs), switches, industrial I/O, bus interfaces, and many mainstream generators and analyzers will not benefit from the additional backplane bandwidth. Thus, one of the most valuable aspects of the PXI Express specification is its ability to route both PCI and PCI Express signaling to slots so that PXI peripheral modules and PXI Express peripheral modules can be used together in the same chassis and systems. As a result, many instrument manufacturers will continue to base PXI products on PCI signaling because the current PCI architecture serves the need. You can choose the modules that are the best fit for your applications, without being concerned whether they are using PCI or PCI Express signaling.

PXI Express Milestones

Passage of the PXI Express specification occurred in September 2005. The first PXI Express controllers and chassis released in April 2006. The initial rollout of PXI Express and CompactPCI Express peripheral modules will occur throughout 2006 and 2007. The CompactPCI Express and PXI Express specification timelines are the following:

PCI Industrial Manufacturers Group (PICMG)

- January 2003 — CompactPCI Express research began
- April 2004 — CompactPCI Express specification development officially began
- June 2005 — CompactPCI Express (EXP.0) specification passed
- February 2006 — First chassis and controllers released

PXI Systems Alliance (PXISA)

- May 2005 — PXI Express specification development officially began
- June 2005 — PXI-1 ECN for hybrid-slot-compatible PXI modules passed
- August 2005 — PXI-5 PXI Express hardware specification passed
- September 2005 — PXI-6 PXI Express software specification passed
- April 2006 — First chassis and controllers released
- August 2006 — First peripheral modules released

With PXI Express, engineers and scientists can now handle numerous new applications, such as high frequency and resolution IF/RF systems, high-speed digital interfaces, and imaging. At the same time, the software and hardware compatibilities of PXI Express also guarantee the growth of the current PXI architecture with many new product releases. Together, compatibility and industry-leading performance ensure the future success of the PXI platform.

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