The Case for AXIe:

Why instrument vendors should actively consider AXIe for their next modular platform.

As modular instruments gain market share in the test and measurement industry, vendors have a choice of architectures. PXI is the most prevalent modular standard, and VXI is the oldest. However, AXIe offers advantages that vendors of instrumentation products should consider. This paper makes the case for AXIe.

Modular architectures are taking market share in automated test applications due to size, speed, flexibility and cost advantages. A number of dynamics are positioning modular instruments to take even more share as the industry addresses new communication and mil/aero challenges. While PXI is the most prevalent of the modular standards, AXIe is the fastest growing. As vendors consider their options, AXIe may be the exact architecture they need to address the applications of the future. For many applications, AXIe delivers a density, performance, or cost advantage over the PXI alternative.

What is AXIe?

AXIe can best be described as the big brother to PXI. Like PXI, it is an open system modular architecture that allows products from different vendors to be integrated into a single chassis. Instead of competing with PXI, it complements the popular standard by offering high performance instrumentation that demands a larger form factor. AXIe can be easily integrated with PXI and traditional instruments into a single test system. AXIe chassis may be as small as two slots, allowing the insertion of even a single AXIe instrument efficiently into a system. The combination of AXIe's performance, density, and scalability, position it as an appealing option for many test applications.

The image above shows 2, 5, and 14-slot AXIe chassis, housing multiple vendor modules. The 5-slot 4U chassis (center) is same height as a PXI chassis.

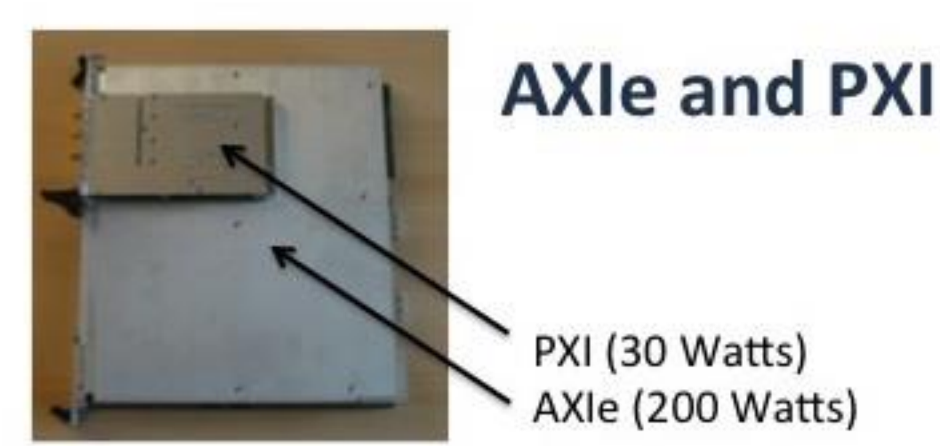
A reader can investigate more details of AXIe in this simple summary: http://axiestandard.org/files/Introduction%20to%20AXIe_final.pdf

More complete information, including all specifications, can be found on the AXIe Consortium website at http://axiestandard.org/home.html

This paper's purpose is not to repeat the architectural descriptions found in those documents, but to present the advantages that the AXIe architecture enables. Among these are density, performance, and cost benefits. Each will be explored in this paper.

Density advantages

AXIe is a large-format modular instrument standard. The image below shows a PXI module alongside an AXIe module to show the larger format of the AXIe module. An AXIe module measures 12.7 inches by 11 inches, nearly six times the area of a PXI module. Furthermore, an AXIe module is 50% wider, 1.2 inches compared to PXI's 0.8 inches. The large format and air vents allow up to 200 watts to be reliably cooled on a single module, compared to PXI's 30 watts.



The image above highlights the difference in modules size between AXIe and PXI.

These statistics show the size of each module, but how do these relate to overall power and component density? For that, one must look at a complete system. Fortunately, the most common AXIe and PXI system configurations are nearly the same size.

AXIe and PXI chassis are often deployed as 4U rack units. The analysis below shows absolute density one gets from each architecture.

The most common AXIe chassis configuration is a 5-slot horizontal chassis, taking four rack units of height (4U). The PCIe (PCI Express) or LAN interface to the test system controller is embedded in the chassis, leaving five instrument slots. Similarly, the most common configuration of PXI is also 4U high, and consists of a controller slot (for a similar interface or embedded controller) and 17 instrument slots. From these configurations, one can calculate the overall rack density of each architecture.

In the PXI case, a 4U chassis supports 510 watts of instrument power, and 5.4 liters of circuitry. In the AXIe case, a 4U chassis supports 1000 watts of instrument power, and 13.5 liters of circuitry. These statistics make it clear that AXIe has a natural 2:1 power density advantage over PXI, and a 2.5:1 circuit density advantage.

In many practical configurations, the density advantage is even greater. Many PXI chassis require an extra 1U of rack space for cooling, since the modules are vertical. This further decreases the density of a PXI system, giving AXIe a 3:1 rack density advantage. 5-slot AXIe systems don't face this constraint, as the airflow remains horizontal. Secondly, the "overhead" circuitry for AXIe and PXI modules is approximately the same, but takes a larger portion of a PXI module's volume to deploy. Thirdly, a typical 4U AXIe chassis contains all the advanced trigger functions of AXIe, where PXI requires an instrument slot to be sacrificed for the same functionality. Add these real world engineering factors, and the density advantages of AXIe can well exceed 3:1.

Some applications don't need this advantage. If an instrument can fit onto a single-slot PXI module, and only a single channel is needed, then there is no density advantage for AXIe. In fact, PXI can have an advantage if all the modules are single slot and different. But as soon as either a single instrument requires significant power or circuitry, or multiple channels are to be deployed, the density advantages of AXIe become apparent. AXIe, like PXI, can support multi-slot modules to increase the available volume and power proportionally.

Performance advantages

AXIe also delivers clear performance advantages. First of all, high-speed instrumentation can take advantage of the improved power and cooling density mentioned above. Additionally, the large board format allows a co-planar design for high-speed signals. This avoids routing high-speed signals between boards, which is difficult, and reduces density even if feasible.

Both PXI and AXIe use PCIe as the primary communication fabric. Even here, AXIe sports an advantage. The new "Wide PCIe" capability of AXIe allows 16 lanes in each direction to PXI's eight. Given the same technology generation of PCIe, AXIe will always have a 2:1 bandwidth advantage.

However, AXIe's bus speed advantages don't stop there. AXIe also includes a 62-lane local bus between adjacent modules. This allows nearly another 4:1 advantage in bandwidth over AXIe's PCIe, and 8:1 over PXI's PCIe, based on the number of lanes alone. Since local bus segments are much shorter, the speed advantages exceed these numbers. AXIe designs have shown transfer rates of up to 80GB/s using the local bus.

	Bus Speed (GByte/sec)		
	PXI x8	AXIe x16	AXIe local bus
PCIe Gen 2	4.0	8.0	31.0
PCIe Gen 3	8.0	16.0	62.0

The chart above shows the maximum speeds of each architecture for a given PCIe technology generation. Bus speed is proportional to the number of lanes. Real world speeds are typically 20% lower. An exception to this is the AXIe local bus- since it travels shorter distances, and is not necessarily tied to PCIe, speeds of up to 80 Gbyte/sec have been demonstrated.

Local bus allows ultra-high speed communication between adjacent modules of an instrument set. Vendors can exploit the local bus beyond just increased data bandwidth, but also high-speed timing and synchronization signals if desired, or even just a convenient method of creating an auxiliary communication bus between modules. A different vendor can use their own local bus segments for completely independent communications at the same time. Thus, the local bus can be thought of as a private high-speed backplane within a backplane.

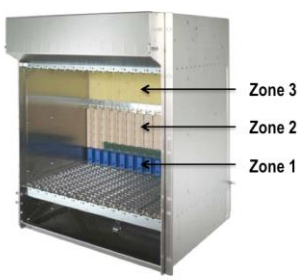
Another high-performance benefit of AXIe is the timing system. Besides 12 parallel trigger lines that span each module, there is a precision trigger/timing subsystem that routes clocks, triggers, and sync signals to and from each module in a low-jitter star configuration.

Cost

AXIe is often positioned at a higher price-performance point than PXI. This is typically true, as a 5-slot AXIe chassis is more expensive than an 18-slot PXI chassis, even when a Cable PCIe interface and System Timing Module are included to create the equivalent PXI system. When measured per-watt or per-volume, AXIe comes out ahead, as one would expect.

However, AXIe can achieve an absolute cost advantage in certain situations. The AXIe-0 specification, a subset of the mainstream AXIe-1 specification, is specifically designed for low cost. AXIe-0 achieves low cost by using a minimal backplane, simple LAN communication and triggering, and a single voltage power supply. AXIe-0 retains the same large module size, but financial models show it can be less expensive than PXI. AXIe-0 modules are upward compatible. That is, they will work in standard AXIe-1 chassis.

Interesting applications for AXIe-0 include mil/aero switching applications currently being served by VXI. AXIe offers a similar board size and slot width to VXI, but on a vibrant new standard. The module size is useful for switching relays, load cards, or any custom development.



AXIe also includes an optional customizable backplane area known as Zone 3. Essential it is an empty space where a custom backplane may be inserted, or signals can be routed. Since standard AXIe-1 modules don't access Zone 3, they may be inserted into a chassis that does so, without conflict. These features together make AXIe an attractive platform for system integrators.

Summary

AXIe brings many platform benefits for vendors looking at next generation applications. Whether it's the emerging 5G communication standard, or advanced mil/aero systems, the multi-channel nature of new applications require a high-density modular platform. AXIe brings the highest density, the highest performance, and the most flexibility of any open modular platform. This is not to take anything away from PXI. Indeed, most AXIe vendors are also PXI vendors. However, for many emerging applications, AXIe brings benefits that can't be matched in any other architecture.