

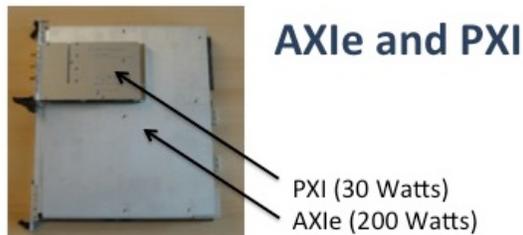
## Introduction to AXIe

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If you've been reading test publications, or speaking with one of several vendors that offer AXIe-compatible products, you may have come across the term "AXIe". What is it? Where is it used? How is it different, or similar, to other instrument standards? These are the questions I aim to answer in this introduction to AXIe.

AXIe is a modular standard of pluggable test instrumentation similar to PXI or VXI, but with some important differences. AXIe is an abbreviation for "Advanced Telecommunications Computing Architecture Extensions for Instrumentation and Test", a reference to the industrial bus standard it is based on. However, it is most useful to compare AXIe to PXI. AXIe is often referred to as the "big brother" of PXI, since it acts like a large PXI system in many aspects, but has supports a larger board format suitable for high power applications. Like PXI, AXIe is an open system, and users may mix and match modules and chassis from multiple vendors. Also, like PXI, AXIe is based on a high-speed PCIe (PCI Express) data fabric, a low latency and high-speed bus. AXIe data communication is so similar to PXI, that a controller perceives the two to be the same, and uses similar IVI or LabView drivers to control the instruments.

If AXIe is so similar to PXI, what are the differences, and why are they needed? This is a good question, and will be the theme for the remainder of this tutorial. The most obvious difference is the module size.



### Module Size

The above figure 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.

What types of applications need these board and power densities? AXIe finds itself deployed in high-speed data converter and digital applications in mil/aero (military/aerospace), semiconductor characterization and test, and high-energy physics. Today, AXIe digitizers range up to 40Gs/s, arbitrary waveform generators up to 65Gs/s, and bit error rate testers to 32Gb/s. AXIe's large format allows high speed digital and

microwave signals to remain on a single coplanar design to retain signal integrity, while reliably cooling the power densities required of high performance instrumentation.

## **AXIe Chassis**

AXIe chassis must be awfully tall to support these larger modules, right? Actually, not. In fact, the smallest AXIe chassis are only 2U rack units tall, half that of a typical PXI chassis. This brings us to the second major physical distinction with PXI: most chassis, at least for small module counts, are horizontal.

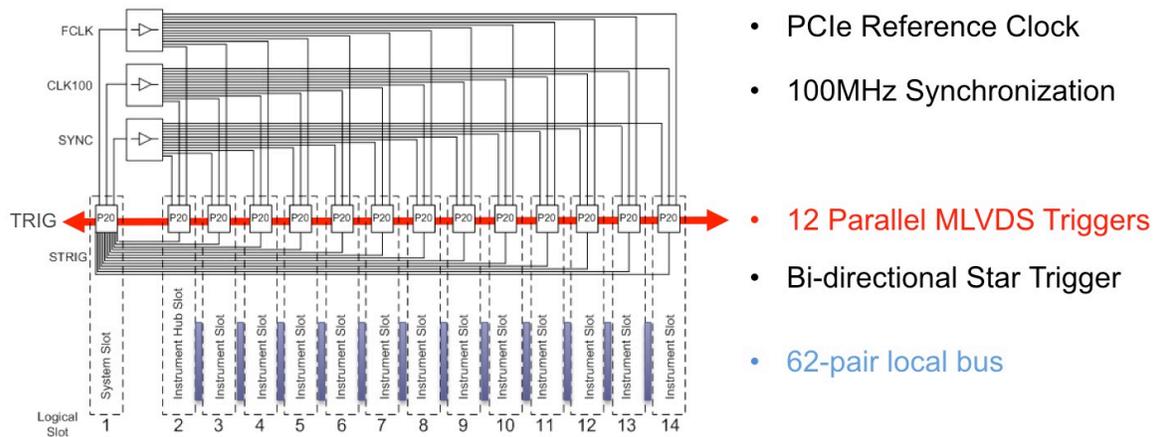
### **AXIe-0 chassis can come in different sizes**



AXIe chassis can come in any number of slots up to 14 per mainframe. However, 2-slot, 5-slot, and 14-slot are the most common. AXIe's large format exists nicely within a horizontal chassis. Rack space used is proportional to the number of slots needed, and horizontal orientation offers some significant cooling advantages. The availability of 2-slot chassis means a user doesn't need to find an armada of AXIe modules to make their chassis investment worthwhile, even a single module or two may be efficiently deployed, perhaps alongside other test instrumentation. Indeed, some vendors have deployed what appear to be stand-alone instruments in a small AXIe chassis, with the knowledge that their users then will have the option to mix and match with other AXIe instruments in a larger chassis if the application demands it.

## **Triggers and Synchronization**

AXIe includes a high performance triggering system to complement and coordinate the modules. There are 12 parallel triggers lines that span all slots, as well as a hub-based trigger and timing subsystem that originates from the system slot. This "star" configuration originating from the system slot supports low jitter bidirectional trigger lines to each slot, a precision 100MHz clock, and a synchronized SYNC line for qualification. Altogether these create a very high performance trigger and timing subsystem.



It should be noted that the “system slot” mentioned above may be an actual slot, or embedded in the chassis. Typically, 2 and 5 slot chassis have the system functionality included within the chassis, while 14 slot configurations have a specified AXIe slot that a system module plugs into.

## Data Communication

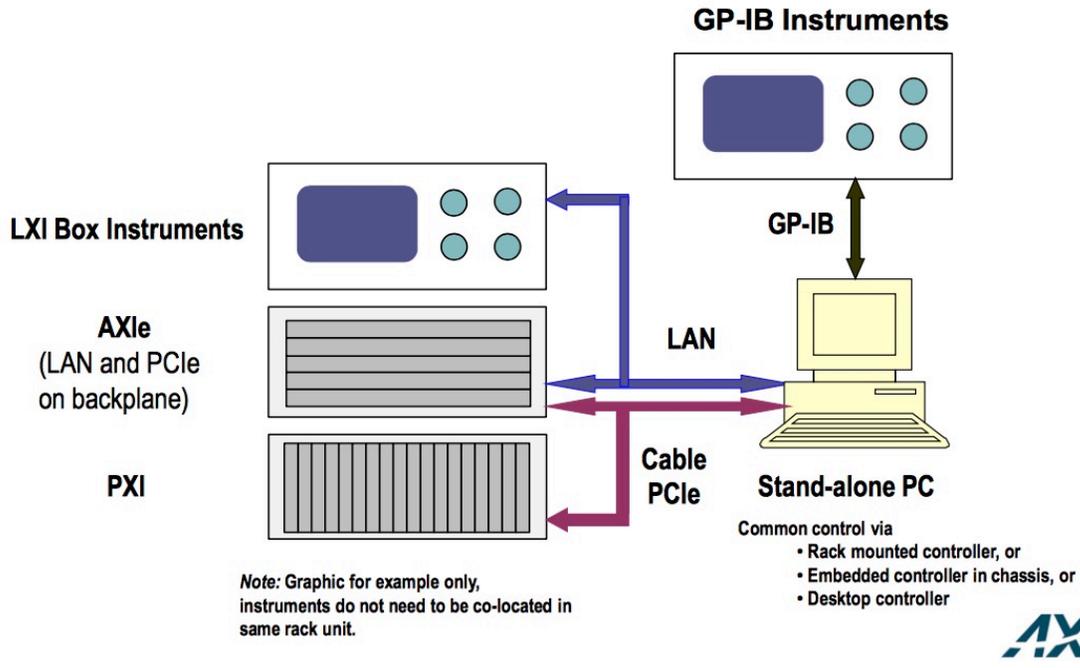
As mentioned previously, AXIe supports communication to each module via PCIe. Today, each link is a x4 link, which equates to 2GB/s nominal throughput with a typical Gen 2 system. The AXIe Consortium has approved an extension to AXIe that will widen the links up to x16, with proportionally more throughput.

To control the modules, Cable PCIe (a flexible high speed cable) is connected between an external controller and the system module. If the system module functionality is embedded in the chassis, as is often the case, there will be a Cable PCIe connector on the chassis. Users may also choose to deploy an embedded controller, one designed into the AXIe format. In this case, the embedded controller is simply plugged into one of the AXIe slots.

In addition to PCIe, an AXIe chassis also routes LAN to each slot. Though most modules are PCIe-based, LAN communication is also allowed, and may deliver new low cost capability in the future.

A unique bus structure to AXIe is called the “local bus”. Referring to the trigger and timing figure above, you can see that the local bus is a set of very short buses that connect from one slot to an adjacent slot, and no further. The short path length, combined with the large number of lanes (62 differential pairs) allows very high data rates. AXIe products have shown 40GB/s and even 80GB/s rates to be transferred over the local bus. The local bus itself is protocol agnostic, and can include timing as well as data signals.

# AXIe integration with Rack and Stack



AXIe systems rarely operate alone. Often they are complemented by traditional instrumentation or modular instruments such as PXI in a rack. The diagram above shows how AXIe communication is integrated with LXI, PXI, and GP-IB instruments. Though the figure shows an external PC, the controller may alternatively be embedded within the AXIe or PXI chassis.

## Software

It is important to note, that in the diagram above, the controller perceives the AXIe system to be just another PXI system. Modules are enumerated, identify themselves, and behave exactly as PXI modules. This allows the large existing base of PXI-oriented software to also work for AXIe.

Each module comes with one or more drivers, just as in PXI. These drivers are typically delivered in one (or more) of the IIVI or LabView definitions. AXIe systems have been successfully deployed in numerous Microsoft Windows environments, including LabView, Matlab, Visual Basic, and nearly all C variants. With Linux-based drivers, AXIe system may also be deployed with Linux.

Above the instrument control level, the sky is the limit. Vendors often offer application-specific software that may include spectrum analysis, waveform analysis, or waveform

and signal creation. For digital products they often offer specific protocol support, such as USB or PCIe analysis.

## Applications

As noted earlier, most AXIe applications can be found in mil/aero, high speed digital and semiconductor, and high-energy physics. The mil/aero applications tend to be grouped around advanced military electronics, such as phased-array radar or EW (electronic warfare) simulation. The wide bandwidths and multiple channel nature of these applications tend to be a good match to AXIe.



The AXIe system shown above shows two specialized AXIe chassis from Giga-tronics housing Giga-tronics, Guzik, and Keysight modules to build a closed loop EW tester. Each chassis may be used standalone to perform transmitter or receiver testing.

In the digital space, AXIe is used for characterization and test of high speed serial links. BERTs with speeds up to 32Gb/s characterize the parametric performance of serial links, while numerous products analyze the protocol layers. AWGs with sample rates of 65Gs/s can emulate new signals with included pre-emphasis. A completely configured semiconductor test station is available for use in characterization and manufacturing test.

High-energy physics takes advantage of AXIe's numerous multi-channel digitizers. With channel densities up to 32 channels per slot, and speeds up to 40Gs/s, AXIe offers a high density architecture for signal capture with precise time correlation.

AXIe is not restricted to the above market segments. Anywhere there is a need for high speed digitizing or signal generation, AXIe may be a good match. Furthermore, as more modules are made available, the number of addressable applications also increases. AXIe-0, a low cost but compatible derivative of AXIe, may expand AXIe into switching and other lower cost applications.

### **For More Information**

The AXIe Consortium [website](#) is a good resource for anyone interested in AXIe. It includes [overviews](#), [articles](#), and detailed [specifications](#) of AXIe. The archive of the quarterly [AXIe newsletters](#) is another good source of information. AXIe is an open system available to any and all vendors. You may view the membership list [here](#). The consortium website attempts list the current AXIe products on its [product page](#). Often, product types are grouped together, so it is recommended to go to the vendors' websites for product details and options.

### **Summary**

AXIe can best be described as the big brother to PXI. 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.