

Announcing AXIe-0: Low Cost Instrument & Switch Architecture



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AXIe-0: Low Cost & Switch Goals

- Situation
 - Large switch systems require large board size, similar to VXI or AXIe
 - Legacy mil/aero applications on VXI struggling to find migration path
 - Custom test modules require significant board area and volume
 - AXIe-1 delivers board area, but is cost-prohibitive for switch systems
 - => A subset of AXIe can deliver the benefits at reduced cost.
- Goals
 - Develop a low-cost architecture for Instruments, Switching, Signal Conditioning, RFIU
 - Applicable to low cost and custom instruments
 - Upward compatible to AXIe-1 systems.
 - e.g. AXIe-0 modules work in AXIe-1 chassis

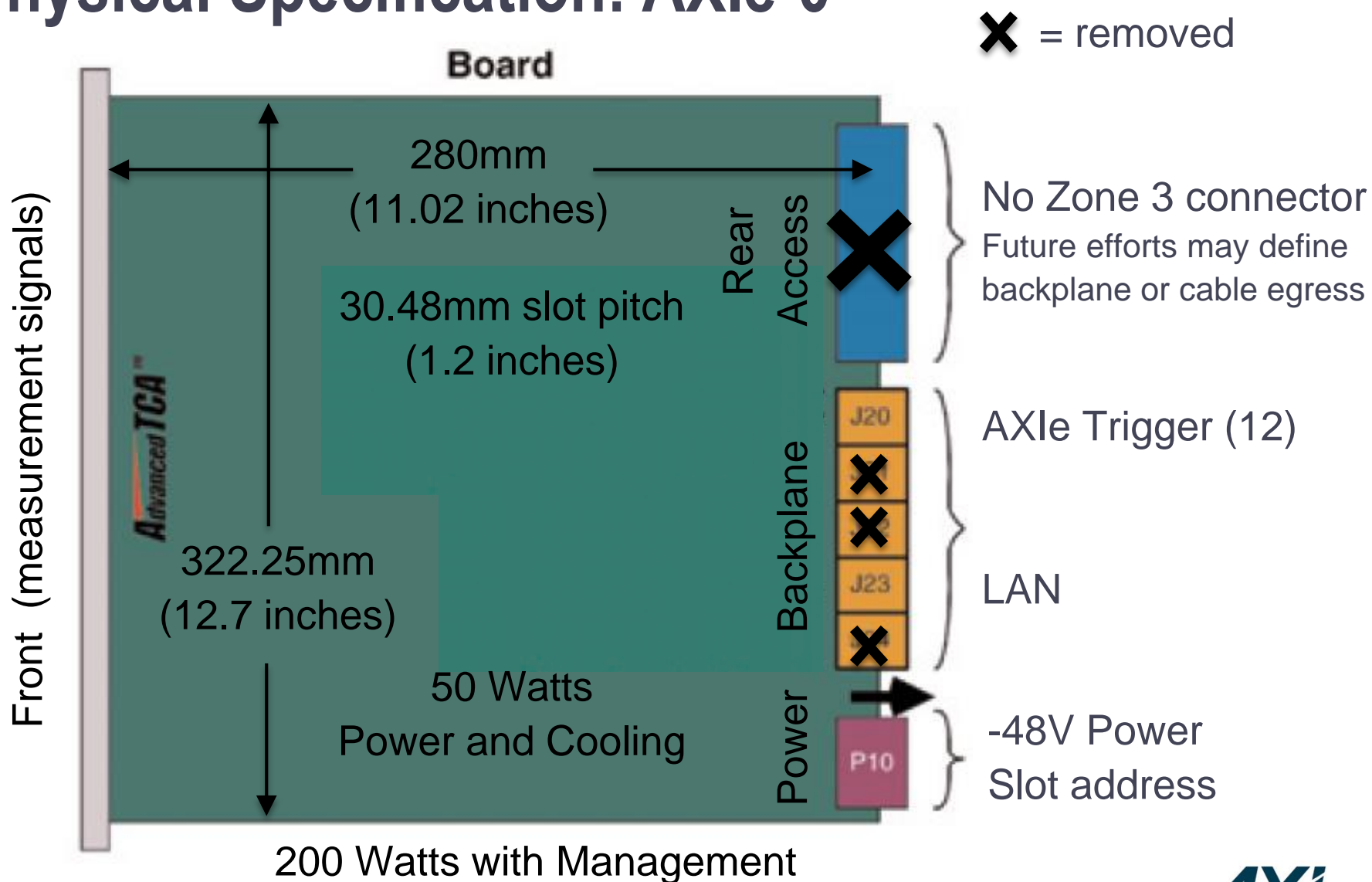
Announcing AXIe-0

- New specification addressing low cost and switch applications.
- Upward compatible: AXIe-0 modules work in AXIe-1 chassis
- Same as AXIe-1:
 - Module size
 - Board area
 - Slot scalability
 - Horizontal and vertical configurations
- Different from AXIe-1:
 - Subset of capability to achieve cost points

AXIe-0 Specification Summary

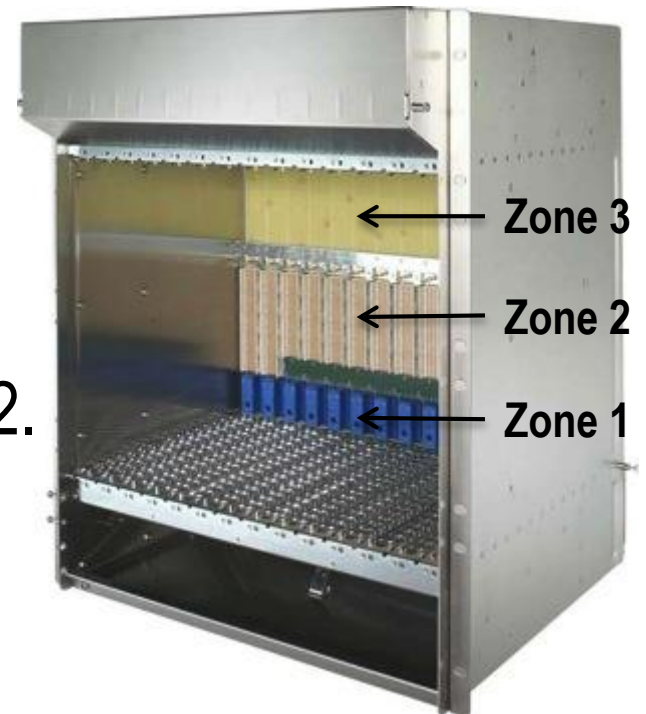
- Entry level chassis = LAN with triggers
 - Uses existing AXIe LAN and trigger resources
 - Reduced management, backplane, connectors => lower cost
 - Non-SCPI LAN for speed (SCPI optional)
 - 12 parallel trigger lines to each slot
 - 50 watts/slot power & cooling without management
 - >200 watts/slot with management

Physical Specification: AXle-0



How does AXIe-0 achieve its cost advantages?

- LAN-interface...
 - reduces backplane layers
 - simplifies chassis functions
 - included on PCs already
- Single power supply voltage (-48V)
 - Avoids over-engineering of multiple rails
- Zone 2 connectors reduced from 5 to 2.
- Zone 3 connectors eliminated
- IPMI management eliminated
 - Up to 50 watts power and cooling w/o management
 - >50 watts can be implement by adding management (200 watts already available)



AXIe-0 chassis can come in different sizes



2-slot 2U chassis



5-slot 4U chassis



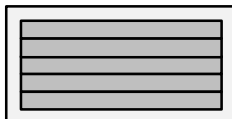
14 slot Vertical chassis

The availability of small horizontal chassis makes AXIe a feasible choice, even for small module counts, alone or with other instruments and architectures.

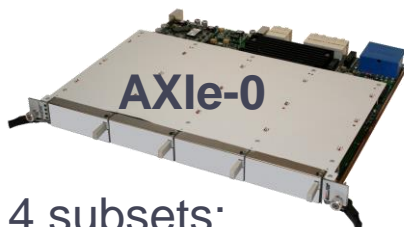
e.g. the “half-filled chassis syndrome” is eliminated

AXIe-0 is upwards compatible to AXIe-1

AXIe-0 Chassis



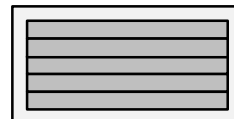
- 50W/slot unmanaged
- ≥ 200 W/slot managed
- LAN
- Triggers



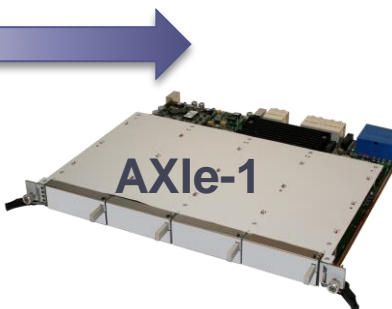
4 subsets:

- Unpowered
- Power only
- LAN
- LAN + Trigger

AXIe-1 Chassis



- 50W/slot unmanaged
- ≥ 200 W/slot managed
- LAN
- Triggers
- PCIe
- Local Bus
- STAR TRIG



Typically:

- PCIe
- High power

Why choose LAN?

- LAN + Triggers meets speed requirements of most switching
 - Non-SCPI LAN brings command latency to sub-millisecond
 - Trigger lines allow hardware switching speeds
 - Easy to use: cycle power of chassis and controller independently
 - Ubiquitous: LAN is present on every controller already
 - Flexibility: Allows non-Windows controllers
- Would PCIe ever be used for switching?
 - Yes, lowest latency for solid state switching and digital
 - PCIe a good match for PXI carrier module
 - PCIe may be added, technically becoming AXIe-1

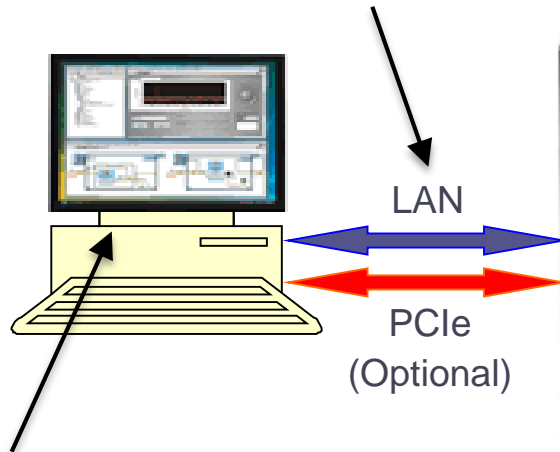
Relationship with LXI

- AXIe-0 modules are essentially simple fast LXI devices
- AXIe-0 uses subset of LXI specification
 - AXIe-0 may take exception to some LXI requirements
- AXIe-0 devices will be discovered along with LXI devices
 - Leverages LXI discovery mechanism
- AXIe-0 modules may be full LXI devices if vendor chooses
- Borrows IEEE-1588 option from LXI for data acquisition applications requiring time synchronization
- Note: To state LXI compliance or to use the LXI reference design requires a vendor to join the LXI Consortium

AXIe-0 incorporates existing standards

LXI protocols

Subset of LXI protocols allows
AXIe-0 devices to be part of LXI systems



IVI drivers

Allows ease of use
with non-SCPI instruments

AXIe instruments

AXIe-0 is upward
compatible to AXIe-1. Both
may be integrated together
in an AXIe-1 chassis

VXI slot spacing

1.2 inch spacing leverages
common fixturing products
developed for VXI.
Provides migration path.

PXI carriers

AXIe-1 allows
integration of PXI
into AXIe



Applications

- Large switching systems and RF Interface Units
 - Mil/aero, electronic functional test
- Custom instrumentation from system integrators or users
 - Large board area and simple development
- VXI replacement in mil/aero
 - Replace large switching networks with AXIe-0
 - Incorporate management for modules >50 watts
 - Integrate PXI where needed using carriers
- General purpose and data acquisition
 - Architecture applicable to many instrument types
 - IEEE-1588 may be deployed when needed.

Timeline

- AXIe-0 announced September 2014
- Preliminary specification in slide format available on AXIe website
 - A “subtractive” standard is easy to document as it merely lists which requirements are removed
- Product development enabled immediately
 - AXIe-1 chassis can serve as development of AXIe-0 modules
- Formal specification efforts to continue
 - Review of specifications as development exposes details
 - Future: Zone 3 analog backplane and fixturing.

Summary

- AXIe-0 defines a low cost instrument and switch architecture
- Based on LAN + triggers
- Non-SCPI programming for highest speed (SCPI optional)
- Incorporates PCI Express and PXI carriers via AXIe-1
- Upward compatible: AXIe-0 modules work in AXIe-1 chassis
- Key applications are switching, mil/aero test, VXI replacement

AXle-0 Technical Description & Preliminary Specification

Nomenclature

- AXIe-0 describes managed and unmanaged devices
- AXIe-0M describes AXIe-0 managed devices
- AXIe-1 is base architecture specification
- AXIe-1LC is a recommended subset of AXIe-1 that adds PCIe to AXIe-0 in a very cost effective manner
- While the following slides principally describe AXIe-0, some AXIe-1LC references are included in the appropriate sections.

AXIe-0M (Management)

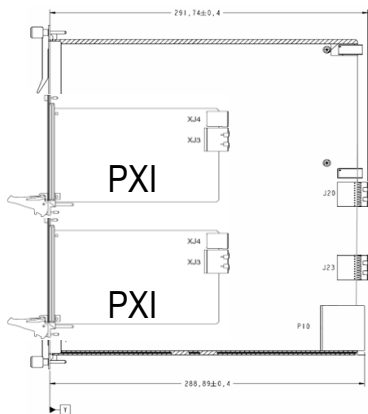
- Without Management:
 - All chassis will power and cool to 50 watts/slot
 - Supports LAN, 12 AXIe triggers
 - No PCIe, local bus, e-keying, or STAR trigger
- With Management:
 - Power/cooling may be increased to > 200watts
 - Allows any feature of AXIe-1

AXIe-0M allows AXIe to migrate VXI applications, even those requiring very high power.

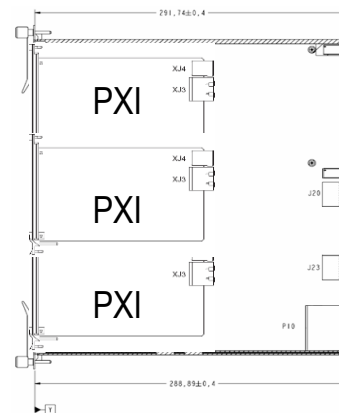
AXIe-1LC

- AXIe-1LC is a low cost subset of the existing AXIe-1 standard
- AXIe-1LC *adds* 1 lane of PCIe (PCI Express) to AXIe-0
 - LAN is always present in the chassis, IPMI required
- Purpose is to support very low latency applications
 - PCIe suitable for solid state switching
- PXI carrier supported on AXIe-1 or AXIe-1LC
 - Allows PXI switches in AXIe

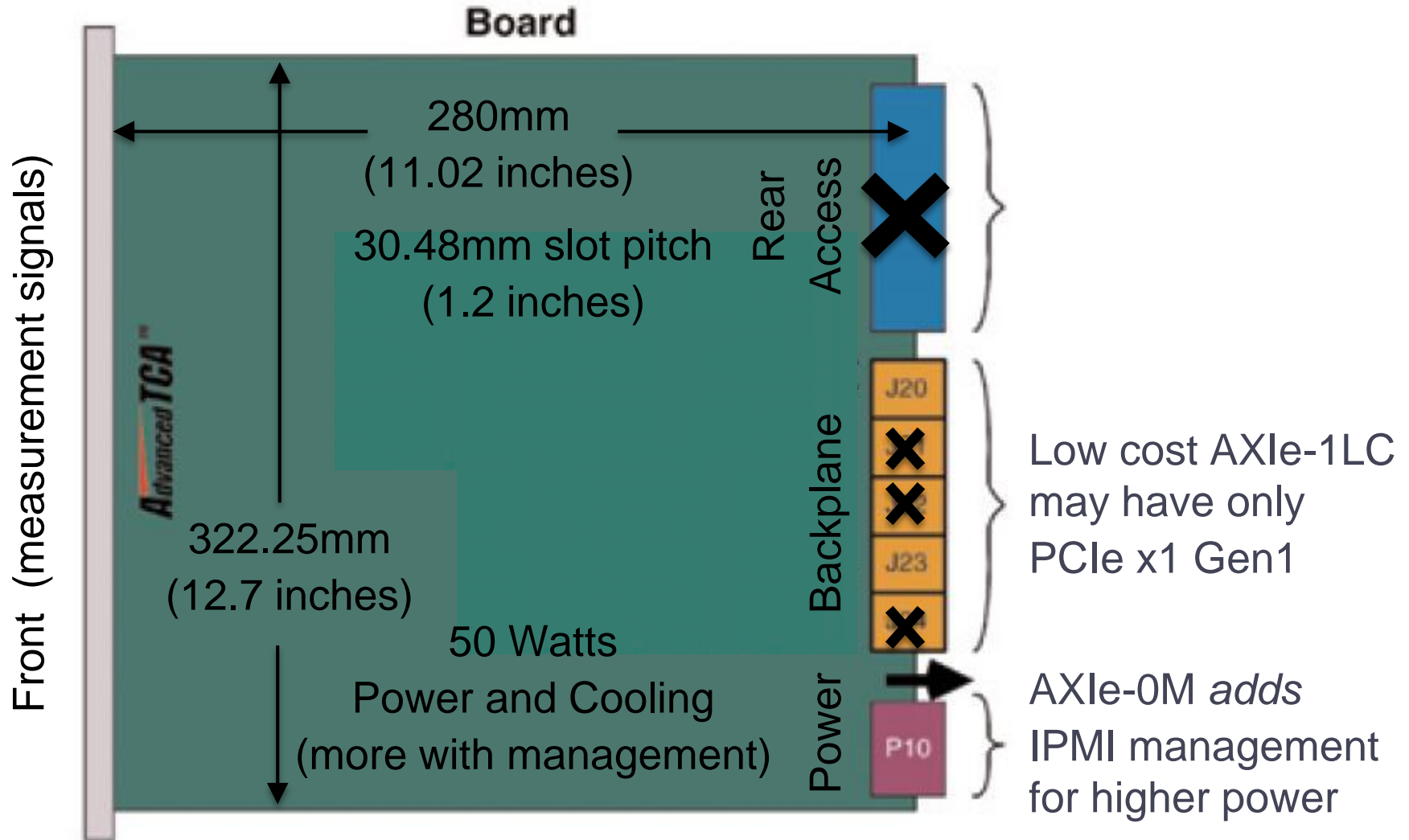
2 modules if
faceplates
remain



3 modules if
faceplates
removed



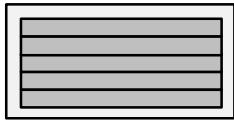
Options: AXIe-0M, IEEE-1588, AXIe-1



IEEE-1588 adds synchronization
for data acquisition

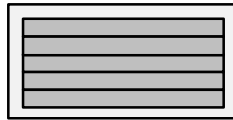
Expanded compatibility view

AXIe-0



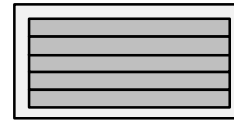
- 50W/slot
- LAN
- Triggers

AXIe-0M



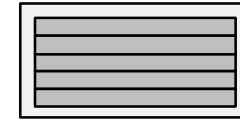
- 50-200W/slot
- LAN
- Triggers
- IPMI Management

AXIe-1LC

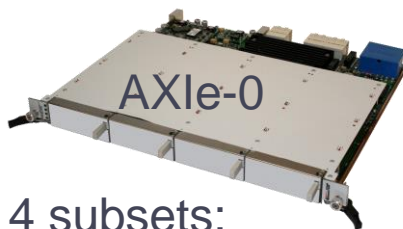


- 50-200W/slot
- LAN
- Triggers
- IPMI
- PCIe x1 Gen1
- 18 pair local bus

AXIe-1

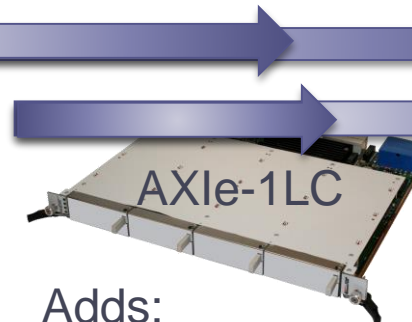
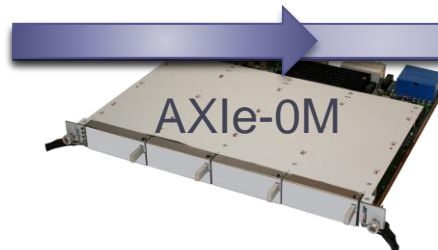


- 50-200W/slot
- LAN
- Triggers
- IPMI
- PCIe x4 Gen2
- Local Bus
- STAR TRIG



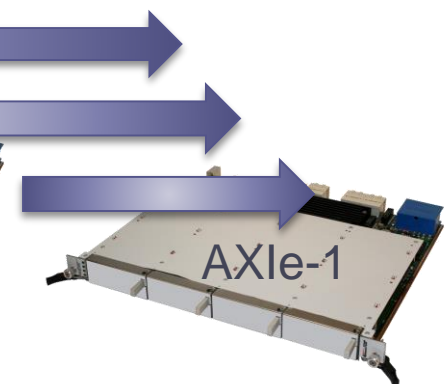
4 subsets:

- Unpowered
- Power only
- LAN
- LAN + Trigger



Adds:

- PCIe Switching
- PXI Switch carrier



Technical Issues

- AXIe Chassis and System Module
- Module and Chassis Size
- Power and Cooling
- Connectors
- Synchronization
- Geographic Addressing
- PCIe and PXI carriers
- IPMI requirements
- Zone 3 options (cable access, analog backplanes)
- Mass interconnect
- LAN protocols and LXI compliance

AXIe Chassis and System Module

- An AXIe-0 chassis MAY be configured with an explicit slot for an AXIe System Module (ASM) or have the functionality built into the chassis as an Embedded System Module (ESM)
- Observation: For cost and space reasons, the ESM design is expected to be prevalent.
- An AXIe-0 chassis with ESM or ASM has:
 - Power and cooling ≥ 50 watts/slot
 - LAN switch to each slot
 - 12 parallel trigger lines
- An AXIe-0 chassis MAY add additional capabilities beyond AXIe-0 minimum
- Note: the term “slot” in the following slides denotes instrument slots, not an ASM slot.

Module and Chassis Size

- All AXIe-0 modules are standard AXIe-1 module size
- AXIe-0 chassis may be any number of slots or orientation
- AXIe-0 modules may be single or multiple slot width
 - A module may be any integer number of slot widths
 - Power and cooling limit is increased proportionally
 - Geographical addressing is determined by the lowest logical slot number. This is typically the left-most slot of a vertical module.

Power and Cooling

- Power

- AXIe-1 and ATCA currently state 15 watts as allowed without IPMI management.
- All current AXIe-1 chassis can cool significantly more than 15 watts
- AXIe-0 will increase unmanaged power to 50 watts per slot
- An AXIe-0M chassis implements IPMI management for added power and cooling
- An AXIe-0M module may request >50 watt power and cooling by implementing IPMI management
- AXIe-1 chassis must cool at least 50 watts/slot for upwards compatibility

Connectors - chassis

- All AXIe-0 chassis MUST include the Zone 1 connector
 - Supplies -48V power
 - Includes slot ID
 - IPMI is NOT required
 - IPMI MAY be included. If so, the chassis is AXIe-0M compatible
- AXIe-0 chassis MUST include Zone 2 connectors P20 and P23
 - The LAN base fabric is routed on P23 to each slot
 - AXIe Trigger [0:11] are routed on P20 to each slot
- AXIe-1LC adds PCIe and management to AXIe-0
 - PCIe x1, Gen 1 plus associated Fabric Clock routed to each slot
- Zone 3 is not required for AXIe-0 or AXIe-1
 - Optional Zone 3 configurations may be addressed in future standards

Connectors - module

- AXIe-0 modules MAY include the Zone 1 connector
 - Non-powered modules need no backplane connectors
 - Powered modules use -48V power
 - Non-programmable powered modules need only Zone 1
 - Modules MAY detect slot location via slot ID on Zone 1
- AXIe-0 modules may implement Zone 2 connectors P20 and P23:
 - A module MAY include P23 for LAN capability.
 - A module MAY include P20 for trigger capability.
- AXIe-1LC adds PCIe and management
 - A module MAY include PCIe x1, Gen 1 capability on P20 and P23.
 - If so, the module is AXIe-1LC compatible
- Zone 3 is not required for AXIe-0 or AXIe-1
 - Optional Zone 3 configurations may be addressed in future standards

Synchronization

- AXIe-0 chassis MUST route MLVDS trigger lines TRIG [0-11] to all slots
- AXIe-0 modules MAY access TRIG lines
 - If a module accesses any TRIG line, it MUST access all twelve [0-11]
 - EXCEPTION: PXI carriers only map [0-7] due to PXI's eight triggers
- An AXIe-0 chassis MAY route TRIG lines to external connector(s)
 - This allows interfacing to external instrumentation
- An AXIe chassis MAY report the state of each trigger line
- An AXIe chassis MAY generate trigger signals on AXIe TRIG lines

Geographic Addressing (Slot ID)

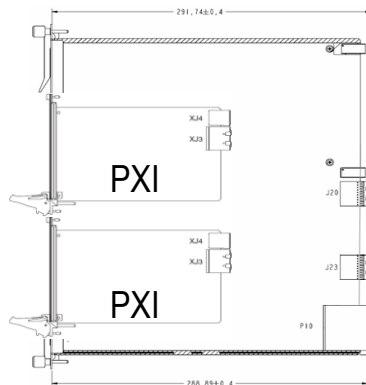
- AXIe-0 chassis MUST include Slot ID coded into Zone 1 connector
 - This identifier may be detected by the module
- AXIe-0 modules MAY detect and report their slot ID
 - An AXIe-0 module will report slot location either through an instrument driver or through a yet unspecified standard command
 - Note: If a module implements AXIe-0M, it may report slot ID via standard IPMI technique
- AXIe-1 or AXIe-1LC modules will report slot ID via standard IPMI techniques

AXIe-1LC (adding PCI Express)

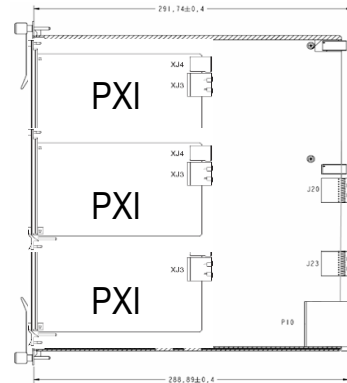
- An AXIe-LC chassis MUST include AXIe-0 capability
 - This allows all AXIe-0 modules to work in AXIe-1LC chassis
- An AXIe-1LC chassis MUST include PCIe x1 Gen 1
 - Single lane PCIe is minimum requirement
 - AXIe-1LC MAY include PCIe x4 (four lanes)
 - IPMI is required for AXIe-1LC
- An AXIe-1LC module MUST support PCIe x1 Gen 1 capability
 - It may also support PCIe x4 capability
 - It must implement AXIe-1 IPMI

PXI Carriers

- AXIe-1 and AXIe-1LC support PXI carriers
- PXI carriers MUST map the PXI trigger lines to the similarly numbered AXIe TRIG [0-7] lines
 - This guarantees that PXI drivers work the same



2 modules if
faceplates remain



3 modules if
faceplates removed

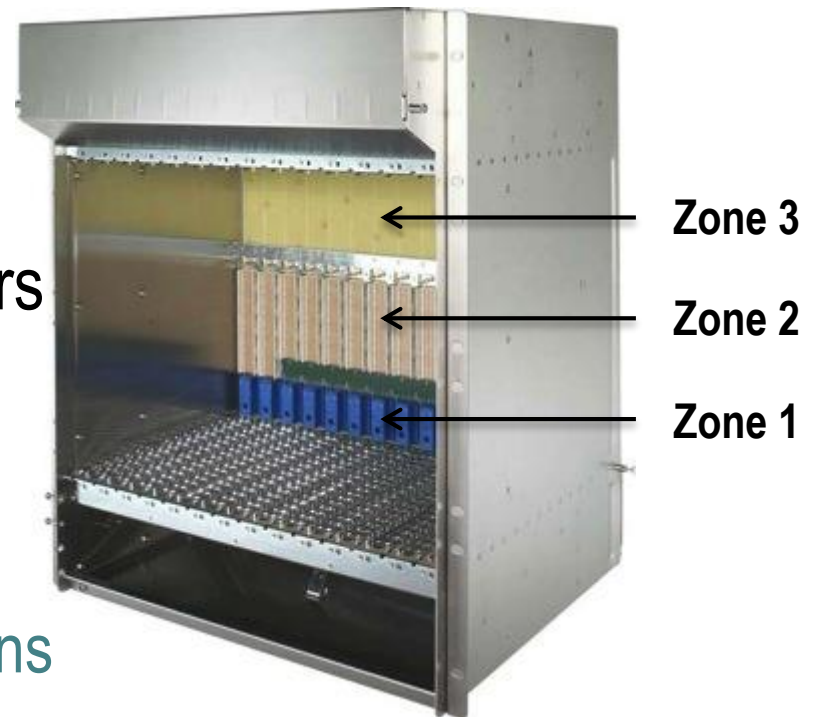


IPMI

- An AXIe-0 chassis is *not required* to support IPMI management
- An AXIe-0 module is *not required* to support IPMI management
- An AXIe-0 chassis or module MAY support IPMI management
 - A chassis or module that supports IPMI management is AXIe-0M
 - The most common use is to support modules >50watts/slot
- All AXIe-1 products, including AXIe-1LC, MUST support IPMI

Zone 3 options

- Today, neither AXIe-1 chassis nor modules support Zone 3 connectors
- AXIe likely to work on future standards regarding Zone 3
 - May include connector attachment points to allow flexible configurations
- Applications include:
 - Cable access through rear
 - Analog backplanes
- Note: it is advantageous to design modules that can operate without Zone 3, even if they have some Zone 3 capabilities



Mass Interconnect

- Mass interconnect for fixturing to the Device Under Test is allowed
- There are no known standardization issues to address
- AXIe leverages VXI's 1.2 inch slot spacing, enabling many current solutions



LAN Communication

- In an AXIe-0 system, a controller communicates with the AXIe-0 modules directly, the the chassis does little more than provide a LAN switch to each slot.
- The modules use LXI protocols for discovery and setup
- Modules offer a web interface for adjusting system setup. This is leveraged from LXI and will work as in an LXI system
- After discovery, the controller may communicate with the module using...
 - High-speed non-SCPI protocols, supported by IVI instrument drivers
 - and/or SCPI
- Web interface for displaying instrument functions is optional.

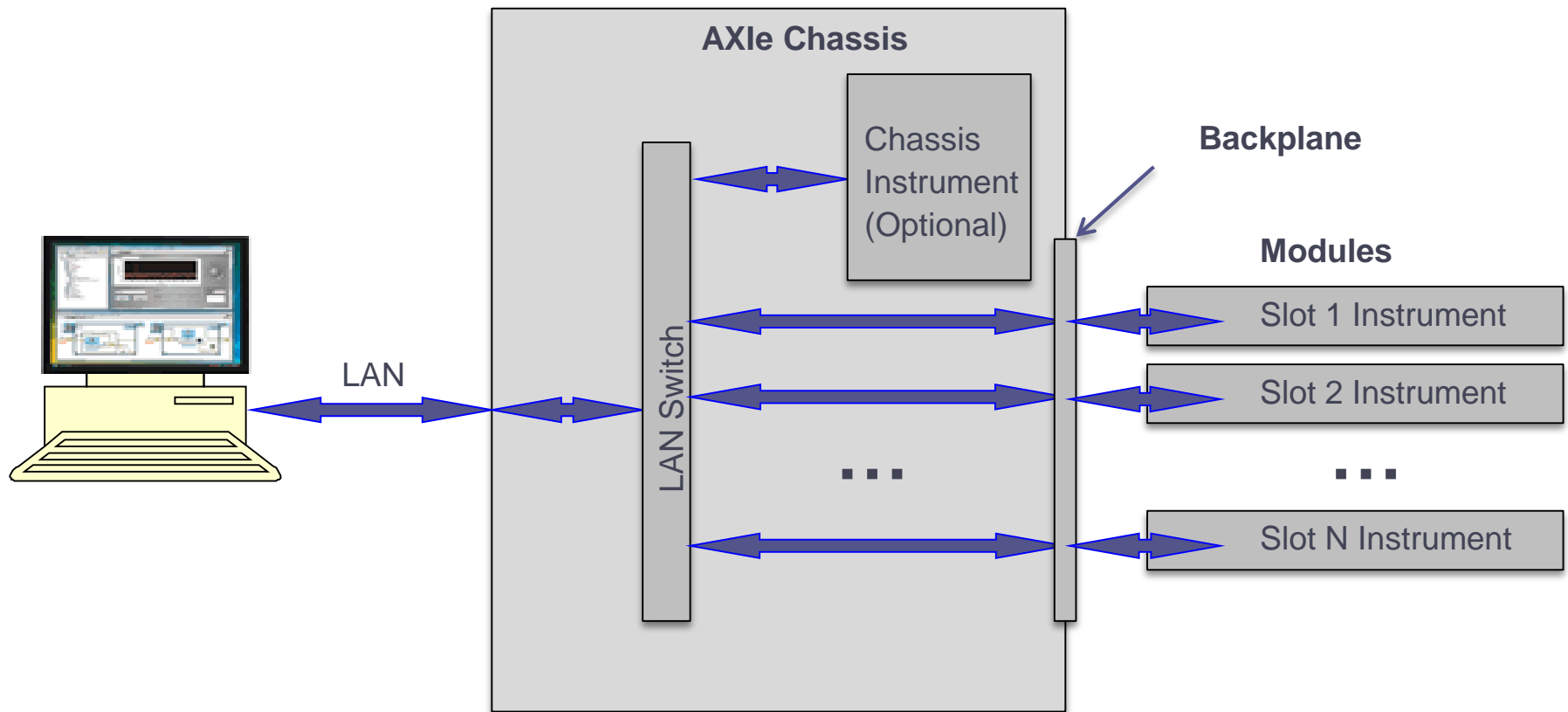
AXIe-0 LAN Protocols

- LAN is distributed from an external controller to each chassis slot.
- AXIe-0 devices MUST comply with a *subset* of the LXI *base* specification to facilitate discovery, setup, and communication
- LXI Extended functions:
 - LXI trigger bus: Not used. Use AXIe triggers instead
 - Event messaging, Clock Synchronization, Time stamped data, Event logs: Optional
- AXIe-0 devices may comply with entire LXI specification
- LAN protocols include:
 - Faceplate indicators
 - Manual switches and buttons
 - Labeling and documentation
 - IP assignment protocols
 - Configuration
 - Web page server
 - Instrument communication and drivers

LAN Protocols – Chassis

- In general, chassis intelligence is low or non-existence, and the instrument functionality is embedded in the modules and drivers.
- A chassis supports one or more external LAN connections to an external controller, and routes this to a switch that brings LAN to each slot.
- A chassis MAY have its own intelligence and associated IP address. If so, that intelligence is called a *chassis instrument*. This intelligence is typically located on the system module, whether an ASM or ESM. The remainder of the document refers to the chassis instrument, but could equally refer to the system module.

LAN Protocols – Chassis Diagram



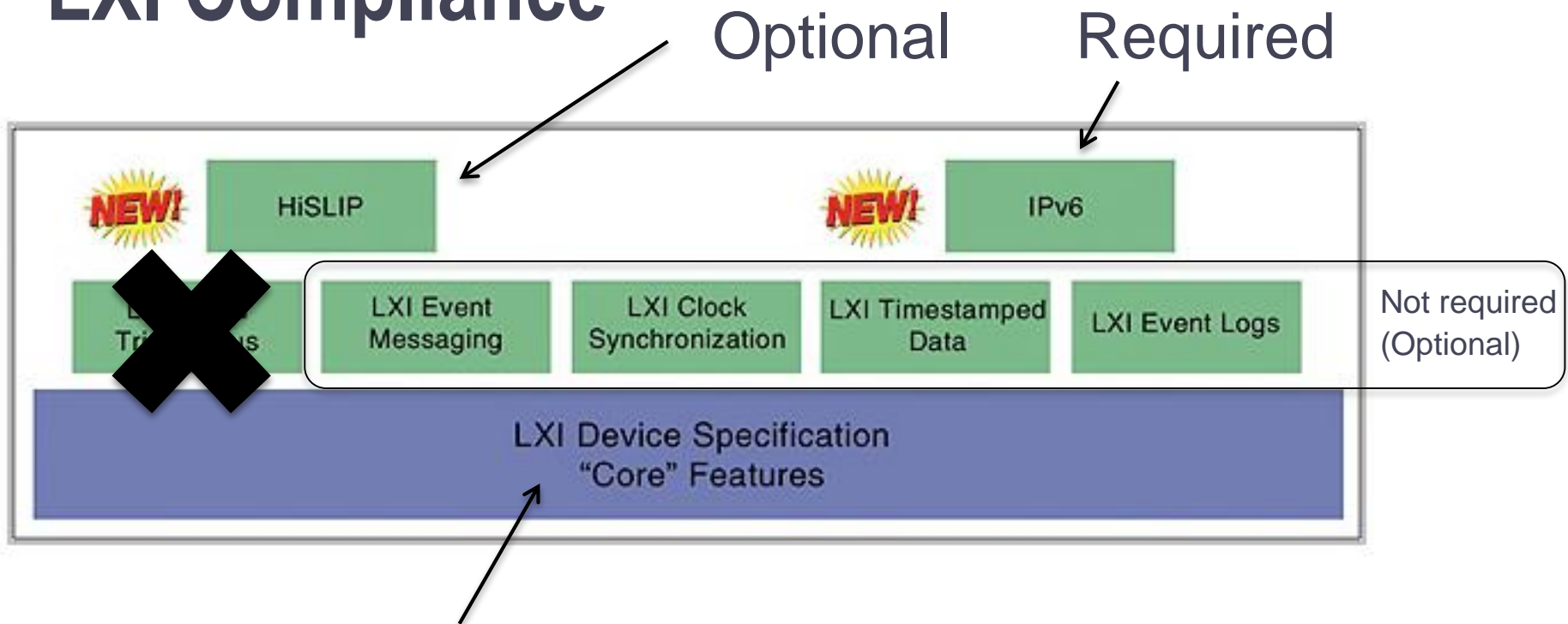
LAN Protocols – Chassis Rules

- AXle-0 chassis MUST include a LAN switch to each slot
- AXle-0 chassis is *not required* to include a chassis instrument
- AXle-0 chassis MAY include a chassis instrument
- AXle-0 chassis MUST support Auto-MDIX at its external connection

LAN Protocols – Chassis Instrument

- Chassis instrument functionality is optional.
- Recommendation: Chassis instrument SHOULD support an ICMP ping responder, which is disableable.
- Recommendation: Chassis instrument should be able to report on state of any TRIG line, and generate triggers on TRIG lines
- Observation: This is an ideal location to implement optional 1588 once for an entire chassis with modules.
- In general, any LAN protocol requirement for AXIe-0 modules is also a requirement for the chassis instrument, if one exists.

LXI Compliance



Subset is required, see next slide

LXI Device Specification may be found here:

<http://www.lxistandard.org/Specifications/Specifications.aspx>

Modules: LXI Compliance by Chapter

- Chapter 1: LXI declarations waived. No requirements
- Chapter 2: Adopt Status Indicators. Waive LXI labeling. See slides
- Chapter 3: No requirements, IEEE-1588 and events are optional
- Chapter 4: No requirements, module to module events are optional
- Chapter 5: No requirements. LXI wired trigger bus not applicable
- Chapter 6: IVI Driver(s) required. See Slide “IVI Drivers”
- Chapter 7: LAN specifications. See Slide “LAN Specifications”
- Chapter 8: LAN Configuration. See Slide “IPv4 and IPv6 Configuration”
- Chapter 9: Web Interface. See Slide “Web Interface”
- Chapter 10: See Slide “LAN Discovery and Identification”

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Faceplate Indicators

- An AXIe-0 module MUST have Power and LAN status indicators as defined by LXI specification
- An AXIe-0 module MUST have an IEEE-1588 indicator IF the device supports IEEE-1588
- An AXIe-0 module MAY have other indicators
- Recommendation: Place indicators at top of faceplate for highest visibility

Labels (1)

- An AXIe-0 module MUST label its AXIe compliance somewhere on the module
- Recommendation: Put the label on the faceplate immediately below the indicators
- Module labels are:
 - AXIe-0 for LAN capable or non-programmable modules
 - AXIe-0M for IPMI Management capability

Labels (2)

- An AXIe-0 module MUST label its MAC address somewhere on the module
- Observation: This may be on the faceplate or on a module shield
- Recommendation: Print MAC address on faceplate if space is available

Faceplate Buttons

- An AXIe-0 device MUST provide a LAN reset mechanism available from the faceplate of an inserted module
- Recommendation: place the button behind a small hole that is accessible only with an inserted tool.
- This function is identical to the LCI (LAN Configuration Initialize) function of LXI, resetting device to this configuration:

Table of items affected by LAN Configuration Initialize Mechanism

Item	Value	Section
IP Address Configuration:		8.6
<ul style="list-style-type: none"> ○ DHCP ○ AutoIP 	<ul style="list-style-type: none"> ○ Enabled ○ Enabled 	
ICMP Ping Responder	Enabled	8.3
Web Password for configuration	Factory Default	9.8
Dynamic DNS (if implemented)	Enabled	8.11.1.1
mDNS and DNS-SD	Enabled	10.3 , 10.4, 10.5.1, 10.7.1


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Synchronization

- IEEE-1588 is not required, but is allowed
 - IF IEEE-1588 is implemented, follow LXI rules
 - Chassis instrument MAY drive AXIe TRIG lines derived from IEEE-1588
 - AXIe-0 modules may enable IEEE-1588 synchronization from their LAN connection
- Module to Module events are not required, but are allowed
 - Note: AXIe TRIG is effective for many applications, events are rarely needed
- LXI Wired Trigger Bus does not exist in AXIe, is not applicable
 - AXIe TRIG bus is very effective substitute
 - LXI Chapter 5 has some very good suggestions to follow for AXIe TRIG


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IVI Drivers

- AXIe-0 modules **MUST** provide one or more IVI drivers
 - IVI-C is preferred, others recommended
- Protocol between driver and device is vendor-specific
 - AXIe-0 devices **MAY** use non-SCPI cryptic commands
 - AXIe-0 devices **MAY** use SCPI
- AXIe-0 devices **MUST** implement Device Identity indicator
 - This uses the LAN Status indicator
- AXIe-0 devices that detect slot location **MUST** report slot location via their IVI driver
 - Will standardize syntax for this

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- Chapter 9: Web Interface. See Slide “Web Interface”
- Chapter 10: See Slide “LAN Discovery and Identification”

LAN Specifications

- AXIe-0 modules are not required to implement Auto-MDIX
 - Chassis Auto-MDIX is sufficient for all modules
- MAC address MUST be displayed as specified in “Labels” slide
- AXIe-0 modules MUST implement Ethernet Connection Monitoring
- AXIe-0 modules MUST support GbE
 - AXIe-0 modules autonegotiate speeds below by default.
 - 10 Mbits/s IS NOT required
 - TBD: Do AXIe-0 modules need any speed other than GbE?

Ethernet Speed	Ethernet Duplex Mode	
10 Mbits/sec	Half	Optional
10 Mbits/sec	Full	Optional
100 Mbits/sec	Half	Required
100 Mbits/sec	Full	Required
1000 Mbits/sec	Full	Required

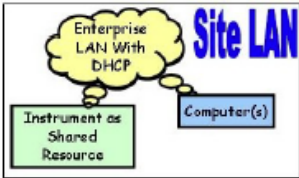

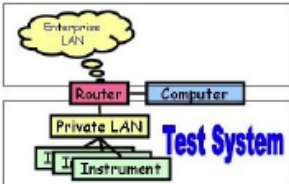

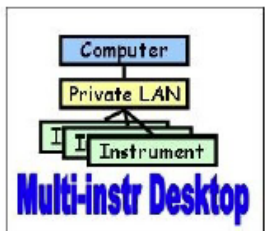
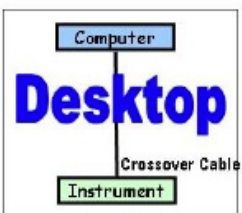

Modules: LXI Compliance by Chapter

- Chapter 1: LXI declarations waived. No requirements
- Chapter 2: Adopt Status Indicators. Waive LXI labeling. See slides
- Chapter 3: No requirements, IEEE-1588 and events are optional
- Chapter 4: No requirements, module to module events are optional
- Chapter 5: No requirements. LXI wired trigger bus not applicable
- Chapter 6: IVI Driver(s) required. See Slide “IVI Drivers”
- Chapter 7: LAN specifications. See Slide “LAN Specifications”
-  • Chapter 8: LAN Configuration. See Slide “IPv4 and IPv6 Configuration”
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IPv4 and IPv6 Configuration

- AXIe-0 devices MUST support IPv4 and IPv6
- AXIe-0 devices MUST support ICMP Ping Responder
 - Significantly helps debugging of system
- AXIe-0 devices MUST use the LXI IP address configuration techniques (shown on next slide)
- AXIe-0 devices SHOULD use Dynamic DNS capabilities outlined in LXI specification
- AXIe-0 device MUST provide LCI (LAN Configuration Initialize) reset mechanism
 - Described in Faceplate Button slide earlier

AXle-0 adopts LXI configuration and discovery methods

	Automatic IP Configuration Methods		Manual IP Configuration Methods
Network Topology	DHCP	Dynamic Link-Local Addressing	Manual IP Address Configuration
	Works on nearly all site/enterprise LANs because they are built with DHCP	 Auto-IP not likely to be used here	Works in all network topologies
	Works on network built with Ethernet router with integrated DHCP server (or equivalent)	 Auto-IP not likely to be used here	Works in all network topologies
	Works on network built with Ethernet router with integrated DHCP server (or equivalent)	Works on network built with Ethernet switch/hub (i.e. w/o DHCP)	Works in all network topologies
	 DHCP not likely to be used here	Works on 2-node network built with a crossover cable (no DHCP)	Works in all network topologies

Modules: LXI Compliance by Chapter

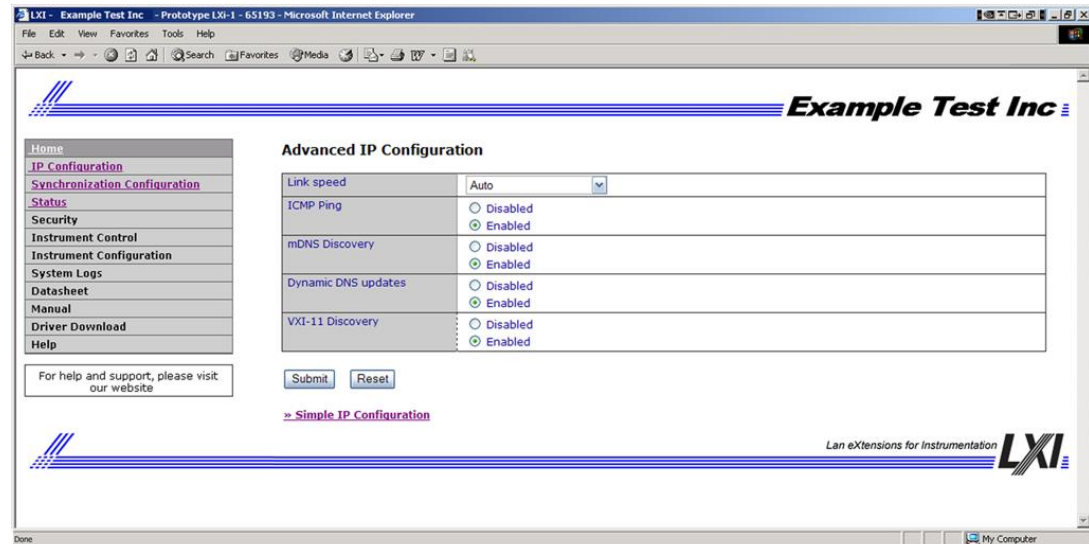
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Web Interface – Welcome Page


- The primary LXI welcome page shall display the following information in a read-only format.
 - LXI Device Model
 - Manufacturer
 - Serial Number
 - Description
 - LXI Extended Functions
 - LXI version
 - Hostname
 - MAC Address <XX-XX-XX-XX-XX-XX>
 - TCP/IP Address <DDD.DDD.DDD.DDD>
 - Firmware and/or Software Revision
 - IEEE 1588 PTP Current time [If IEEE 1588 is implemented]
 - Current source of time
 - LXI Device Address String [VISA]

Web Interface – Configuration Page

- The LAN configuration page shall contain the following parameters to configure the LAN settings:
 - Hostname
 - Description
 - TCP/IP Config. Mode
 - IP address 15
 - Subnet mask
 - Default Gateway
 - DNS Server(s)



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LAN Discovery and Identification

- AXIe-0 modules MUST support mDNS discovery protocol from LXI
 - VXI-11 *not* required
- IPv4 and IPv6 required
- AXIe-0 modules MUST support port 5025 ScpiRaw sockets
- Only required SCPI commands:
 - *IDN? - Identifies instrument
 - AXIe:Slot? - Identifies slot number. Exact syntax TBD
- All other communication may be cryptic and fast
- Recommendation: Provide IVI driver(s) for instrument, particularly when using cryptic commands

Simple AXIe-0 Devices

- AXIe Consortium will investigate a simpler subset of the LAN protocols.
 - Can we implement IP assignment via slot ID?
 - Can we have chassis modify most significant bits of slot ID?
 - How do we correlate a module to a particular chassis?