LXI - Modular Instruments
Autotestcon 2016: Modular Instrumentation in T&M Panel
Customer Benefits of Combining LXI & Modular

**LXI**
- Remote / distributed
- Web access / control
- Compatibility / interoperability
- Easy setup / config
- Simplified programming
- Cost savings
- High performance

**Modular**
- Speed / performance
- Open Solutions
- Custom Solutions
- Choices
- Scalable
- Size reductions / reduced footprint
- Cost Savings

http://www.lxistandard.org/About/Benefits.aspx
What is LXI?

- **LXI is the LAN Standard for Test & Measurement**
  - Use the connection you already know!
  - LXI is the robust system backbone for today and tomorrow, and it lets you easily connect the system you need: big or small, local or remote.

- **What separates an LXI instrument from a LAN instrument?**
  - Consistent set of LAN communication services
  - LAN discovery and configuration support
  - Standard web page
  - IVI driver
  - Interoperability testing
  - Extensions for triggering and synchronization
Success of LXI

Major milestone in 2016

Over 3500 LXI conformant instruments

“The total LXI instrumentation market was estimated to have generated $644.0 million in 2012.” (Frost & Sullivan)

3568 Instruments
303 Product Families
41 Instrument Vendors
51 Member companies
LXI - Modular Instruments Today (PXI, AXIe, VXI, Proprietary)

Agilent / Keysight, Bustec, EADS, Keithley, Pickering, Teradyne, VTI, and more …
LXI – Modular Hybrid Instrument

Test Computer

LXI Discovery
- VISA
- LXI Discovery Tool
- Vendor Discovery Library
- Utilize LXI Standard discovery protocols

Programmatic Interface
- IVI Driver
- Vendor library (optional)
- Vendor proprietary instrument control and data transfer protocols
  - SCPI
  - High level command language / scripting / remote procedure interface
  - Low level modular HW manipulation

Interactive Instrument Interface
- LXI web Interface
  - Configuration
  - Interactive control (optional)
- Vendor proprietary user interface

LXI-Modular Instrument

LXI Compliant Instrument Interface
- LXI Discovery Protocols
- LXI Configuration Protocols
- LXI Web Interface
  - LXI required configuration
  - Optional interactive control
  - Opportunity to leverage the LXI Reference Design Implementation

Modular Instrument Control and Data Interface
- Vendor defined command / data interface and LAN protocols used
  - Optimized for specific instrument requirements
- Vendor instrument firmware routines manage
  - Instrument command / data interface
  - Modular HW manipulation

LAN
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
LXI Reference Design and Implementation

- **LXI v1.4 Reference Design and Implementation Supports**
  - LXI Core + Extended Functions (IPv6, HiSLIP, Event Logging, Event Messaging)
  - Scalable (Windows 7, Ubuntu Linux, low-end processors); members can customize source

- **Key Benefits**
  - Reduced LXI member development and maintenance cost - free license to LXI members
  - Customer benefits - broader global adoption of LXI - more competition/ features/choices

- **Timeline:**
  - LXI Reference Design version 1.0 released March 17, 2016
  - LXI v1.5 – minor update approved October 2016
HSSub Integrates Three Key Components: **Foundation Base with Core Instruments and IO Expansion Instruments**

- **HSSub Foundations**
  - PXI Express Chassis and HSSub PC
  - HSSub TriFlex App Framework – tight integration through software and firmware infrastructure
  - Interfaces to ATE computer as an LXI box
  - Various Foundation configurations available

- **Core Instruments**
  - Runtime Defined Instruments with fast general purpose test processing
    - Real-time computing for upper-level protocols
    - FPGA-based hardware for lower-level protocols
  - Configured in less than one second
  - Capable of direct UUT I/O

- **IO Expansion Instruments (IOXI)**
  - Work as low-level extensions to Core Instruments
  - Provide peculiar low-level interface or protocols support
  - Built by Teradyne or third parties
The Key HSSub Architectural Advantage is the Hierarchical Three-Tier Processing Architecture

- **Tier 1**: High-Speed Subsystem
  - Core Instrument
    - Test-Defined FPGAs
      - UUT Latency: several ns
  - RT Processor
    - Test-Defined FPGA
    - Bus #1
  - RT Processor
    - Test-Defined FPGA
    - Bus #2
  - RT Processor
    - Test-Defined FPGA
    - Bus #3

- **Tier 2**: Real-Time Processors
  - UUT Latency: 10s of us
  - RT Processor
  - RT Processor
  - RT Processor

- **Tier 3**: Windows PC
  - UUT Latency: 10s of ms

**Test Station Computer**
LXI - Modular Standards

- Currently there are no LXI-Modular instrument control and data transfer industry standard protocol investigations underway
  - Discussed briefly at the October 2014 IVI Foundation and LXI Consortium meeting – decision was to not pursue the effort at this time.

- Contact the LXI Consortium if you are aware of some specific LXI-Modular standard opportunities
  - Customer use cases
  - Requirements
  - Solution alternatives
    - Existing
    - New standard / protocol developments
LXI Future
Technology Trends

• “Internet of Things” technology impacts
  – Wireless, Network, Cloud, Security, Standards
• Mobile, Cloud / Client Architectures, Cloud Computing
  – IT management and security changes
  – Drive enterprise mobile platforms
  – Applications in the cloud; personal cloud
• “Industry 4.0”
  – Real-time Networks
Security

Embedded Controllers Are Entry Points For Cyber Crimes

Possible LXI Security Areas to Investigate:

- Authentication: All communication with the LXI device should be authenticated.
- Secure Communication: Secure encrypted communication.
- Embedded Firewalls: Limit communication to known trusted hosts.

UL CAP: Underwriters Laboratories Cybersecurity Assurance Program

- UL 2900 – series of standards to test security of network connectable products and systems
Real-time Networks

• Characteristics
  – Network-wide precision clock reference
  – Limit network delays to a well-known small value
  – Limit non-time-sensitive traffic interference

• Applications
  – Telecom, Aviation, Data Acquisition, Scientific, …

• LXI Clock Synchronization Extended Function
  – IEEE 1588-2008 (V2.0)

• Key technologies to watch
  – IEEE 1588: Edition 2017 (V2.1)
    • Layered architecture, high accuracy, redundancy, security
  – IEEE 802.1 TSN / AS (Time-Sensitive Networking, Audio Video Bridging)
    • Time-sensitive transmission of data
  – Off-the-shelf silicon solutions (Intel i210/11)
    • IEEE 1588 / 802.1 AS support
More Information on LXI

• Visit website
  http://www.lxistandard.org/

• LXI Consortium Meeting and Plug Fest – Boston, MA, October 17-19, 2016

• Contact Bob Helsel, Executive Director or any other LXI Board member
  http://www.lxistandard.org/ContactUs.aspx

Thank You!
Backup
LXI Device Specification 2016 (Revision 1.5)

LXI Device Specification 2016 – Revision 1.5 (LXI 1.5)

• VXI-11 based discovery methods optional
• Remove unnecessary recommendations
• Reorganize LXI Standard documentation, Extended Functions into separate documents.
• Simplify LXI specifications for future enhancements and improve the LXI Conformance process
• Standard released October 2016
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
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”
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?

<table>
<thead>
<tr>
<th>Ethernet Speed</th>
<th>Ethernet Duplex Mode</th>
<th>Optional/Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Mbits/sec</td>
<td>Half</td>
<td>Optional</td>
</tr>
<tr>
<td>10 Mbits/sec</td>
<td>Full</td>
<td>Optional</td>
</tr>
<tr>
<td>100 Mbits/sec</td>
<td>Half</td>
<td>Required</td>
</tr>
<tr>
<td>100 Mbits/sec</td>
<td>Full</td>
<td>Required</td>
</tr>
<tr>
<td>1000 Mbits/sec</td>
<td>Full</td>
<td>Required</td>
</tr>
</tbody>
</table>
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
Recent Designs Require Speed, Real-time Processing, Application Flexibility, and Economical Sustainability

**Basic Requirements:**

- **Address Increasing Speed and Complexity** of custom and standard digital buses along with legacy interfaces
- **Provide Real-time Processing** for fast and repeatable UUT interaction including control, data creation, collection, manipulation, and analysis
- **Provide Application Flexibility** with efficient programming and one instrument performing many roles
- **Provide economical sustainability** for the duration of the program
HSSub Integrates With a New or Existing Test System Over Ethernet

HSSub Integration as LXI instrument for Test Station
Windows XP or Windows 7 Computers

Test Station Computer

Standardize Protocol?
Ethernet

HSSub Instrument

LXI Instrument

VXI Instrument

PXI Instrument

GPIB Instrument

New or Existing Test System