LXI Reference Design Overview

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Table of Contents

Introduction

LXI Devices (LAN eXtensions for Instrumentation) are LAN-enabled instruments that conform to a comprehensive set of rules detailed in the LXI Standard (www.lxistandard.org). Major Electronic Test Equipment Manufacturers and Technical Consultants formed the LXI Consortium in 2004, and about 40 companies currently participate and maintain that standard. LXI provides the basis by which test systems built from multiple vendors provide a common interface and experience.

LXI brings LAN into the test system and provides a wide range of flexibility to the test system engineer. In particular, LXI Devices benefit from these major LAN features:

- The ubiquitous nature of LAN
- Its high performance data transfers
- Low cost, readily available infrastructure
- Flexibility for wired or wireless communication
- Local and Remote (synchronized) access
- Abundance of multiple protocols for varied functionality
- Ability to embed Web servers within each instrument

The current number of LXI conformant products surpassed 2600 in June 2014, and there 50 broad categories with many specialized products within those categories.

LAN instrument vs. LXI instrument

A LAN-enabled instrument is one that can be connected and controlled over LAN by a computer. Instruments have had LAN interfaces for many years, but the **LXI Standard** establishes a standardized behavior for all conformant devices when connecting to LAN. This means you can connect a wide variety of products from one or many companies together using LAN, and they all behave in a standardized manner to simplify Test System configuration and communication. Here are major aspects of instruments that are conformant to the LXI Standard and can display the LXI Logo:

- Consistent set of LAN communication services
- LAN discovery and configuration support
- Standard Web page for configuration and control
- IVI driver
- Interoperability testing

This list of requirements to be LXI conformant is not trivial to achieve and significant effort by each vendor occurs for their products to become and remain LXI conformant.

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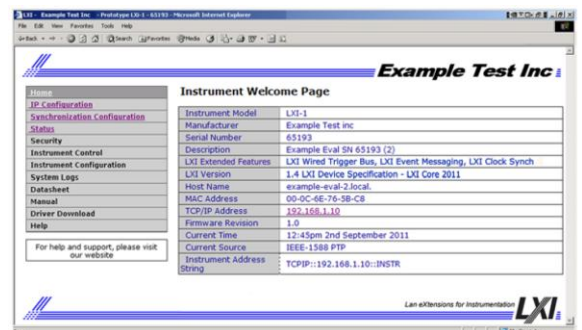
Purpose of LXI Reference Design

One of the strategies of the LXI Consortium to achieve its vision of LXI global adoption and utilization is to provide a "technical blueprint" for vendors to use when building LXI instruments. Several goals were established:

- Ensuring more Test & Measurement (T&M) LXI-conformant instruments are available to our customers, enabling them to have a lower cost, consistent, predictable, and multi-vendor interoperable experience when building network-based T&M test systems.
- Enabling existing and new LXI Consortium members to cost effectively, develop and maintain LXI instruments that support the LXI "Core" and "Extended Function" capabilities.
- Enabling the LXI Consortium to more easily work with its membership to evaluate new and emerging network technologies as additions to the LXI Standard and deploy the additions to the membership through the LXI Reference Design and Implementation.

The LXI standard has reached a stable version number with a set of *Extended Functions*: ***LXI Device Specification 2011 Version 1.4***. This latest specification is perceived to create an entry barrier for some new vendors, and some existing vendors have products that have not migrated beyond earlier versions of the LXI Standard.

Significant improvements in LAN discovery of LXI Devices occurred with LXI Standard 1.3, since it introduced the support of mDNS Discovery. Version 1.4 adopted Extended Functions to provide vendors with the ability to pick-and-choose various advanced features such as LXI Wired Trigger Bus, LXI Timing, LXI Event Logs, and LXI Event Messaging.

LXI Devices conformant to versions before LXI 1.3 are prevented from introducing newer products through technical justification to the older standard. The effort to migrate those products to the current revision of LXI is significant. In addition, existing vendors of products conformant to 1.3 and 1.4 periodically update their hardware platforms and have to adapt their LXI designs to the new hardware and re-apply for LXI conformance due to changes in operating systems, LAN hardware, and LAN drivers.

The LXI Reference Design, funded by the LXI Consortium and its membership, can be used by the majority of vendors to aid transitioning of versions of the standard, ease platform migration, encourage the adoption of Extended Functions and attract new LXI vendors by lowering the entry barriers.

The LXI Reference Design will be experience its first release in Feb 2015 at the LXI Consortium Plugfest. Members will be able to evaluate the reference design beginning at that time.

Benefits of the LXI Reference Design

The following pulls together the overall benefits of the LXI Reference Design and specifically calls out the common and group-oriented benefits:

- Lower barriers to LXI entry
- Reduces design cost
- Makes it more likely to pass the LXI Conformance test the first time
- Use of LXI logo gains more market acceptance
- Fewer support issues since members can use the support documents created by the LXI Consortium

Members who make Software Products

- Creation of test platform allows testing of software products
- Fewer software support issues if vendors are basing on a reference model

University Members

- Porting of Reference Design into hardware and software platforms as university

Vendors who only make products prior to LXI 1.3/1.4

- Lower barriers to product migration
- Ensure support for mDNS Discovery as VXI-11 Discovery is eventually removed
- Lowering long term design costs
- Easier to create new products that are 1.4 Conformant

## Vendors who have progressed to 1.3/1.4

- Provides a route to migrate new hardware platforms to LXI
    - Reduce design costs
    - Reduce barriers to Extended Functions inclusion
    - More surety of fist time conformance test pass
- Provide support across more variety of hardware and operating systems
- More cohesive approach to LXI across divisions of the company
    - Reduction in engineering costs and easier support

LXI Reference Design Components and Architecture

Each LXI Device is required to supply an IVI Driver to control LXI Devices. The IVI Driver provides a common interface between LXI Devices and shields the programmer from the specific command language (native language) used in various LXI Devices. A concept called Native Driver also exists for software such as NI's LabVIEW or MathWorks' MATLAB, where developers write a specific driver using the LXI Device's command language. This gains the benefit of creating a driver interface that is well adapted for the particular Application Software.

If a particular Application Software does not use a driver to control the LXI Device, the terminology Direct I/O applies. Instead of interfacing with an API (Application Programming Interface), the LXI Device's command language embeds directly into the source code of the Application Software.

The Figure below illustrates a summary view of using the IVI Driver or Direct I/O. The IVI Driver can communicate through VISA or other vendor-supplied interface software. Replace the Application Software with NI LabVIEW, and the IVI Driver box with an NI LabVIEW driver, and you have another method of driver control. Place the LXI Device command language directly into the source code of the Application Software and interface through VISA, the Client Side API, or the Socket, and you have Direct I/O control.
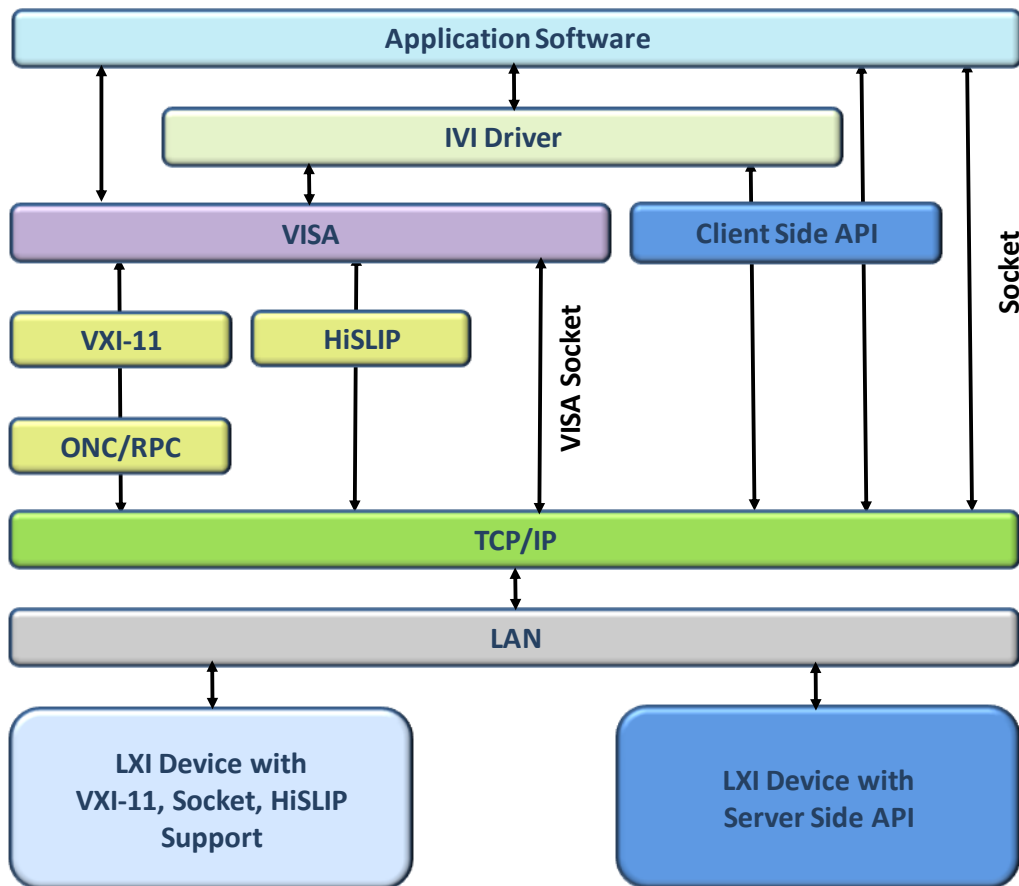
The LXI Reference Design focuses effort on the lower interaction between TCP-IP layer and the LXI Device's LAN interaction. It is a significant effort to implement the interactions between the layers of LAN protocol, provide LAN discovery, general communication, Web-page setup of proper LAN configuration, etc. The LXI Reference Design addresses these base and more advanced capabilities.

The following diagram focuses on the LXI Reference Design interaction with the previous diagram:
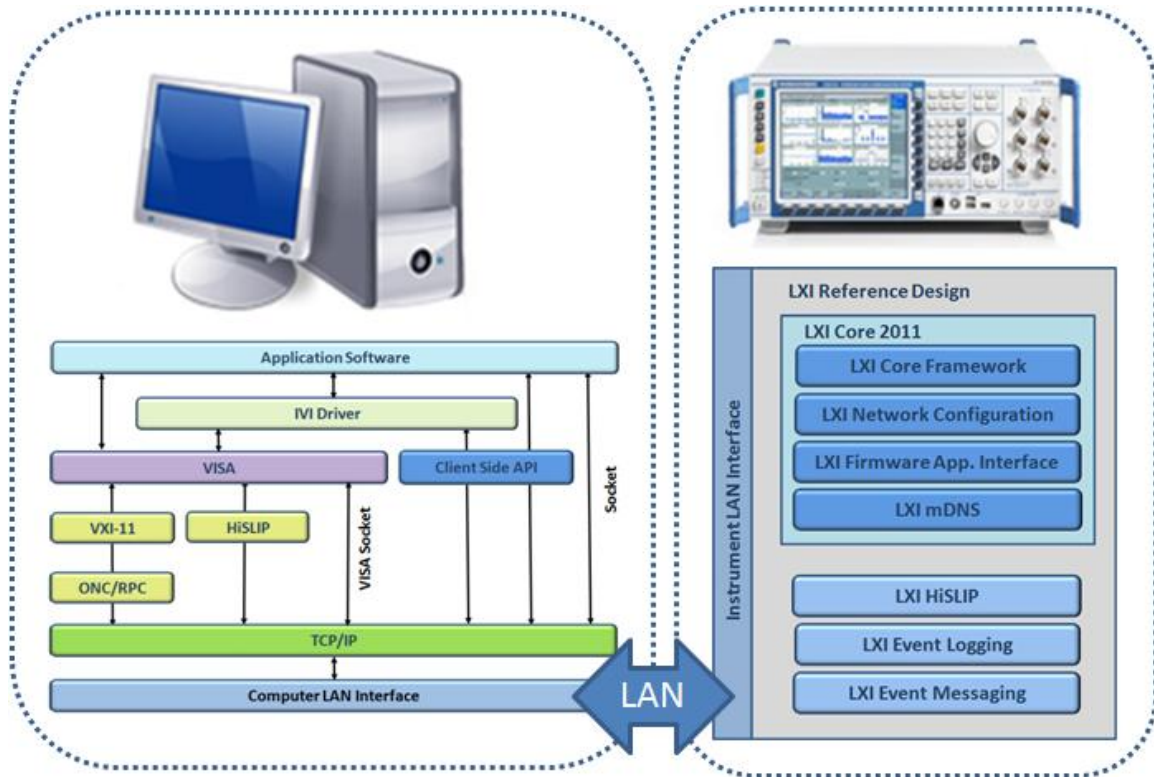
Modules in the shaded region encompass the base or Core set of features provided by the LXI Reference Design. These are required by every LXI Device to be LXI conformant.

- LXI Core Framework
- LXI Network Configuration Module
- LXI Firmware App. Interface Module
- LXI mDNS Module

Extended Functions of the LXI Core 2011 standard include the following:

- LXI HiSLIP Module
- LXI Event Logging Module
- LXI Event Messaging Module

The LXI Reference Design covers all these LXI components, which do not require any vendor specific hardware. Therefore, the modules on the bottom line of the above LXI Reference Design - the LXI Wired Trigger Bus, LXI Clock Synchronization, and LXI Timestamped Data - are omitted from the design.

The LXI Reference Design has been implemented in C++ for the Windows, Linux i386 and Linux Arm platforms. It is intended to be easily portable to other systems and especially to low-end systems.

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Key Module Information

Web Server

Each vendor may adapt his implementation and use any Web Server of their choice, but the following two approaches are provided:

- The minimalist approach, - using Civitweb, a small free Web Server, which is directly embedded into the software with its source code
- The sophisticated approach – using NginX, a complex Web Server.

Network / IPv6

IPv6 can be activated or deactivated at compile time.

mDNS

The mDNS module uses Apple's free Bonjour implementation for Windows and Linux and works for both IPv4 and iPv6

HiSLIP

HiSLIP is the largest of the modules. It is intended to be integrated closely into the vendor firmware. The interfaces and the interactions between HiSLIP and vendor firmware have been the focus of testing by vendors such as Rohde&Schwarz and Keysight Technologies.

LXI Reference Design Package Contents

- UML Design Model, created with Enterprise Architect. It contains all requirements, all classes, and several sequence diagrams and state diagrams
- A Design Document as a PDF export of the model, enhanced with additional documentation
- The Source Code plus unit test source code, ready to use with Microsoft Visual Studio on Windows or Eclipse on Linux
- HTML documentation of the classes and their methods, created with Doxygen.
- A "How-To" document, helping users to get started

LXI Reference Design Testing

As indicated in the Package Contents, there are unit tests included, covering the basic functionality of the modules. These unit tests can be used as regression tests. Ultimately, the LXI Conformance Test Suite is used to detect problems, of which the LXI Consortium will be performing these tests to verify the design.

LXI Reference Design Support

TSE Plazotta is the developing company contracted by the LXI Consortium to implement and document the LXI Reference Design, with the help and input of participating LXI Members. LXI Members can begin to integrate the LXI Reference Design into their firmware, and TSEP will provide support on a consultancy basis and can also offer training. This can cover the concepts, configuring the LXI Reference Design, introducing unit tests and giving an overview of the LXI Conformance Test Suite.

TSEP can also off premium support where Vendors may contact TSEP directly in case support is needed for integrating the LXI Reference Design into their particular firmware implementation. Alternately, TSEP can take over the integration of the LXI Reference Design into vendor firmware.