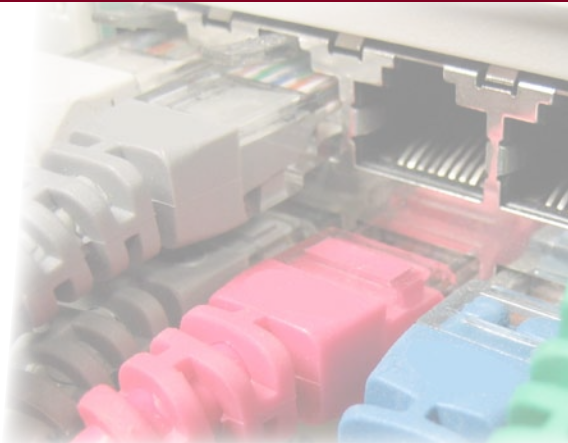


# LAN eXtensions for Instrumentation



## The LXI Primer

**Version 1.1**



# The LXI Primer

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# 1.0 Introduction

This document is intended to help you understand LXI products. Further information can be found on the LXI Consortium Web site, including full product listings and specification details: [www.lxistandard.org](http://www.lxistandard.org).

## 1.1 What is LXI?

With more than 50 of the top test and measurement companies sponsoring and developing this technology, and over 2000 certified products in more than 220 different product families, LXI is the standard for Ethernet control of instrumentation. By standardizing and extending the LAN to instrumentation support, LXI simplifies the use of Ethernet for test systems, providing a low-cost, cross-platform computer interface that can be controlled at any distance.

LXI enables the connection of intelligent instrumentation which supports distributed processing of measurement data and provides a high bandwidth interconnect system for supporting applications with high data demands.

LXI provides new possibilities in system design—local, remote, distributed, and time-aware. LXI's compact, flexible package, high-speed I/O and reliable measurements meet the needs of R&D, design, validation and manufacturing engineers delivering electronics for the aerospace/defence, automotive, industrial, medical, and consumer electronics markets.

LXI is designed to be compatible with other instrumentation platforms, making it easy to create hybrid test systems from multiple vendors and platforms.

## 1.2 Network Basics

This section provides a short overview of Local Area Networks (LANs), the underlying technology of LXI. Note that details of the TCP/IP protocols will not be provided in this document. Additional guides for using LXI, including the best practices to connect LXI devices to the LAN, can be found in the Resources section of the LXI Web site at:

[www.lxistandard.org/Resources/GuidesForUsingLXI.aspx](http://www.lxistandard.org/Resources/GuidesForUsingLXI.aspx)

A LAN is defined as a group of computers or instruments that are physically connected in close proximity to one another and communicate via a protocol such as Ethernet. LANs can vary in size from just two interconnected devices (PC, server, router, instruments, etc.) to thousands, and a router is used to communicate between devices and other networks.

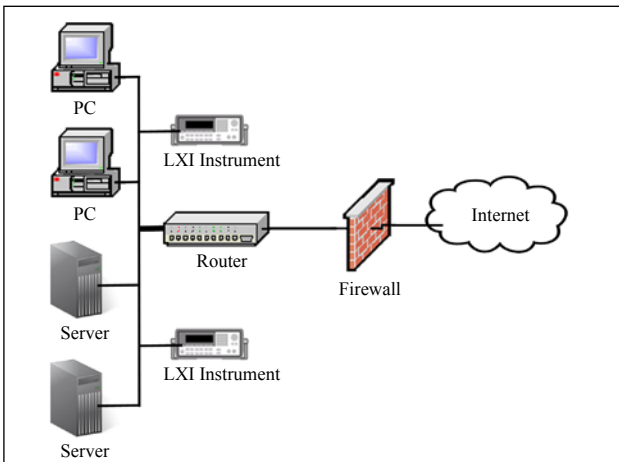


Figure 1 Typical LAN Network

Sometimes it is preferred to create a private or isolated LAN, where devices are interconnected to each other but not to the Internet or any other networks by disconnecting the router from the Firewall and Internet.

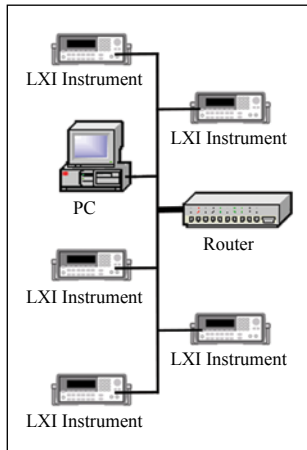


Figure 2 Private LAN Network

For distributed applications or remote testing and diagnostics, where devices span different regions or countries, the use of a Wide Area Network (WAN) is required.

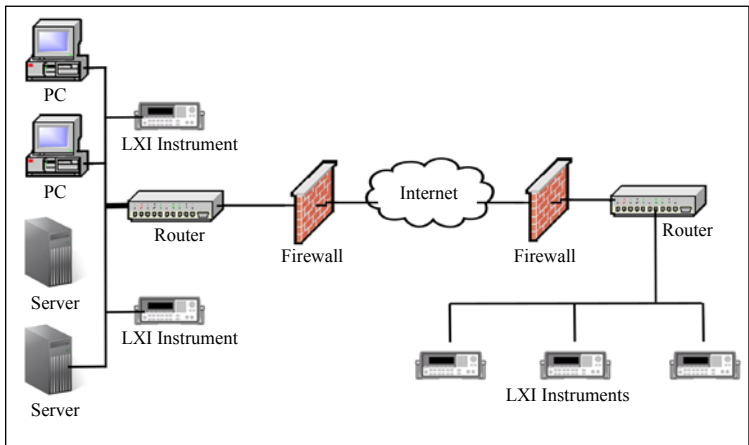


Figure 3 Example of WAN Network

### ***1.3 LXI vs. GPIB***

For more than 30 years, the General Purpose Interface Bus (GPIB) has been the standard communication interface between a controller and rack instruments, allowing test engineers to easily connect and control multiple devices from different vendors. The LXI standard, introduced in 2005, presents system integrators with a fast and efficient alternative for communicating with instruments. LXI overcomes many of the limitations and costs inherent to GPIB. GPIB systems require special cables and controllers which add cost to the overall system. LXI systems based on LAN have an infrastructure comprised of low-cost Ethernet cables and switches that are readily available in the consumer electronic industry.

LXI instruments leverage all of the benefits of LAN technology. Unlike other bus technologies, an LXI-based test system can scale from a small network in a laboratory, all the way up to a distributed, global system connected to the Internet. Currently, LXI instruments are available with Ethernet speeds of 100 Mb/s and 1 Gb/s. The present Ethernet infrastructure features speeds up to 10 Gb/s and will be even faster in the future. Thanks to backward compatibility requirements, present day LXI instruments will continue to operate in the future as network speeds continue to increase. As a result of the increasing network speeds, LXI instruments have much faster block data transfer rates than instruments using slower buses such as GPIB. Some LXI instruments also support advanced intra-device synchronization and triggering mechanisms that improve test throughput efficiency.

Best of all, LXI devices integrate seamlessly into existing test systems that use GPIB or modular architectures such as VXI, PXI, PXI Express or AXIe. This allows you to migrate to LXI when you are ready.

## ***1.4 LXI Core Features***

By standardizing and extending LAN, LXI offers new possibilities in system design – local, remote, distributed, and time-aware. Details regarding the LXI specification can be found at [www.lxistandard.org](http://www.lxistandard.org). The following is a summary of the key features of the LXI Core specification:

### **1. Open industry standards**

LXI is based on widely used industry standards such as TCP/IP Ethernet, IPv4/IPv6, Web browsers and IVI drivers.

### **2. High-speed Ethernet I/O**

LXI is based on Ethernet technology, the most widely accepted communications interface in use today. Ethernet I/O provides backward compatibility and standard connections. Nearly every computer is manufactured with an integrated Ethernet interface, and networking hardware is becoming increasingly inexpensive.

### **3. Built-in standardized Web interface**

Many test and measurement instruments provide Ethernet/LAN connectivity, but the LXI standard ensures that instruments support W3C-compliant browser-based information in order to be compliant with the LXI standard. With the Web interface users can:

- Easily configure and operate the instruments from a graphical user interface (GUI)
- Collect and analyze data without software programming
- Operate instruments remotely, either across the lab or across the globe



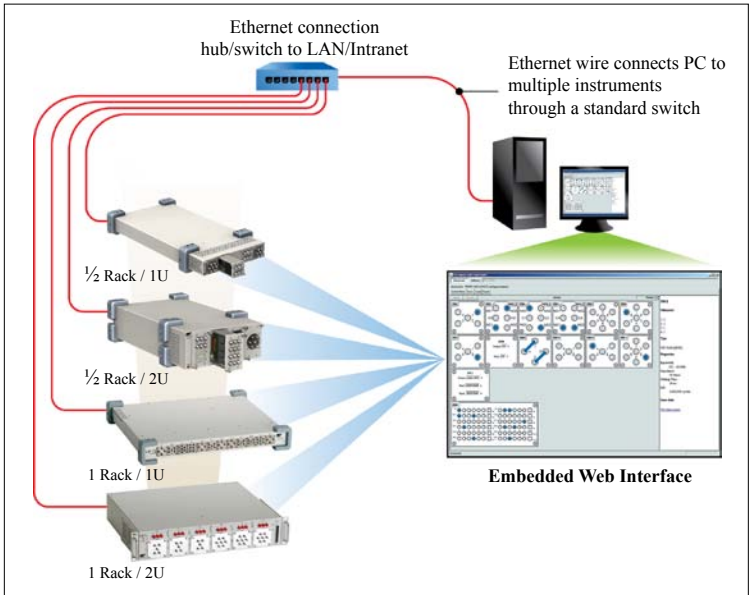


Figure 4 Example of Standardized Web Interface

#### 4. Interchangeable Virtual Instrument (IVI) drivers

All LXI devices include an Interchangeable Virtual Instrument (IVI) driver for programmatic control. The IVI driver provides a consistent programming interface for all LXI devices. The IVI standards ensure that the driver works well in a variety of programming environments, provide high performance interfaces, and ease program development and maintenance.

LXI instruments optionally provide IVI class-compliant drivers. Class-compliant drivers also comply with common definitions for classes of instruments and simplify instrument interchangeability. For more information regarding IVI drivers, visit: [www.ivifoundation.org](http://www.ivifoundation.org).

## 1.5 LXI Extended Functions

LXI Device Specification 2011 Version 1.4 is defined as a set of “Core” features and optional Extended Functions, which have replaced the Class model in previous versions. Each extension has conformance requirements in addition to the base class. An LXI device can include one or more of the following Extended Functions:

### 1. LXI Wired Trigger Bus

The LXI Wired Trigger Bus (WTB) is a hard-wired interface to specify input or output configurability, wired-OR, and shielding and cabling for the most demanding triggering applications.

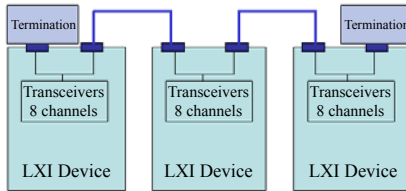


Figure 5 Wired Trigger Bus

This method of triggering increases your accuracy to the nanosecond range compared to software triggering via the LAN, which is typically in the millisecond range.

### 2. LXI Event Messaging

With LXI Event Messaging, an LXI Event message containing triggering information (including a timestamp) is sent directly from one device to another via the LAN, without computer intervention, which improves execution speed.

LAN-based triggers provide programmatically triggered events through driver commands from the controller to the LXI device or by message exchange between LXI devices. They emulate traditional hardware triggers but can carry information that hardware triggers cannot such as trigger slope and time stamps based on synchronized system clocks.

### **3. LXI Clock Synchronization**

LXI clock synchronization inherits IEEE 1588-2008, a protocol used to synchronize real-time clocks with sub microsecond accuracy in devices of a networked distributed system. This allows common timer events to be tied to absolute times for very precise triggering and synchronization and also enables the correlation between instruments in order to aid monitoring and debugging.

### **4. LXI Timestamped Data**

LXI Timestamping enables the capability of marking a LAN event at a point in time – events such as triggering, measuring, or connecting channels. You can understand what happened in time sequence in your test programs.

### **5. LXI Event Logs**

The LXI Event Log utility contains records of LAN events that have occurred, permitting observation of an instrument – or of an entire system – in action. The event log helps you understand what is happening in your instrument or system.

### **6. HiSLIP**

The HiSLIP Extended Function leverages the HiSLIP standard created by the IVI Foundation to create a fast control interface, extend the features provided by VXI-11 (refer to section *4.1 Software Overview* for more details), and emulate the capabilities of GPIB devices. HiSLIP also operates over IPv6 networks.

### **7. IPv6**

The world is being forced to adopt IPv6 as IPv4 address spaces on the Internet run out. The IPv6 Extended Function has been adopted by the LXI Consortium to ensure that the LXI vendors approach IPv6 in a consistent way before its widespread use in test systems occurs and ensuring products can comply with government requirements for IPv6 readiness.

## ***1.6 Benefits of LXI***

Below are some of the key benefits of using LXI products. For a full list of LXI benefits visit: [www.lxistandard.org](http://www.lxistandard.org).

### **1. Guaranteed Compatibility**

Before a product is certified as LXI compliant, it must be tested by a certified third party to ensure that it conforms to the LXI specification. Test engineers are assured that combinations of LXI products will integrate well together and that there is a consistent user experience between products.

### **2. New Distributed Applications**

LXI's seamless connectivity – local and global – enables new distributed applications. LXI overcomes the challenges of distributed test systems by offering:

- Remote System Control: You can control your remote system, as well as provide support from a distance, which allows more efficient use of expert resources.
- Distributed Systems: An LXI distributed system allows the instruments to be closer to the measurements, reducing cable lengths resulting in less excitation voltage loss or variation.

### **3. Reduced Costs**

LXI lowers costs and improves ROI:

- Lower Costs for Equipment: LXI uses standard I/O for simplified connections. You can use off-the-shelf inexpensive LAN cables and routers or switches. There is no need for special I/O hardware, such as GPIB interface cards or cables.
- Reduced Setup and Development Costs: With LXI, you have faster setup, operation that is easy to verify, and standard drivers available for easier test programming.

- LXI devices include a built-in Web interface to enable configuration and troubleshooting, as well as auto-discovery tools to minimize development time.
- Lower Operational and Maintenance Costs: You can easily connect to test and corporate databases to save operational expense. With LXI, it is possible to perform remote execution, monitoring, and debugging, which saves on maintenance costs.

#### **4. Easy Connect**

LXI based instruments can be freely connected and disconnected to the test system controller without the need for powering down the controller - the Ethernet interface ensures connections can be “hot plugged” in the same way as GPIB systems without risking a controller malfunction. The Ethernet standard can work in noisy environments over long distances with robust error correction and re-try mechanisms.

### ***1.7 LXI Applications***

Since LXI is the standard for controlling instruments over Ethernet, it is well suited for a variety of applications, ranging from small local test systems isolated on a subnet to medium and high channel density applications where the instrumentation hardware is distributed throughout a test system, lab, or separated by a significant distance from the host computer and connected to a company’s corporate WAN or the Internet.

Typical test & measurement applications include: RADAR, communications, aerospace & defense, etc. LXI enables fast, efficient, and cost-effective testing as well as compatibility with the other main instrumentation standards such as GPIB, VXI, PXI, and AXIe for hybrid systems.

Recent application articles can be found in the Resources section of the LXI Web site at: [www.lxistandard.org/Resources/](http://www.lxistandard.org/Resources/).

## 2.0 Setup Your LXI System

### 2.1 Using LXI Discovery Tools

Vendors such as National Instruments and Agilent Technologies have discovery tools built into their I/O library configuration utilities. Discovery tools will help you find and identify the LXI instruments available to your computer on the network. Measurement and Automation Explorer from National Instruments, and Agilent Connection Expert from Agilent Technologies, make it easy to discover LXI devices, connect to their Web interface, and configure them for VISA or IVI communications (refer to section 4.0 *Software* for more information regarding VISA or IVI). If you only intend to communicate with the LXI device through its Web interface, you can also use the free LXI System Discovery Tool available from: [www.lxistandard.org/Resources/LXIDiscoveryTool.aspx](http://www.lxistandard.org/Resources/LXIDiscoveryTool.aspx).

Note: It is not necessary to use one of the LXI Discovery tools above to communicate with the device (refer to section 3.0 *Using Your LXI Device* to connect to its Web interface using its hostname or IP address).



Figure 6 LXI Discovery Tools

## 2.2 Connect to the Device

Connect one end of an Ethernet cable to the back of your LXI device and the other end to your computer, or to a free port on your hub or switch, if you are connecting to a network.

Guides for using LXI instruments, including examples of simple switch and router connections to setup LXI test systems, are available in the Resources section of the LXI Web site at: [www.lxistandard.org/Resources/GuidesForUsingLXI.aspx](http://www.lxistandard.org/Resources/GuidesForUsingLXI.aspx). The following is a more advanced example of a wireless test setup.

Although many instruments do not yet have WiFi today, you can also use low-cost, off-the-shelf wireless devices to connect LXI instruments wirelessly. The following figure illustrates how to create a wireless test setup by replacing the wired Ethernet switch or router with a WiFi router and using Ethernet bridges to convert the Ethernet signal to WiFi.

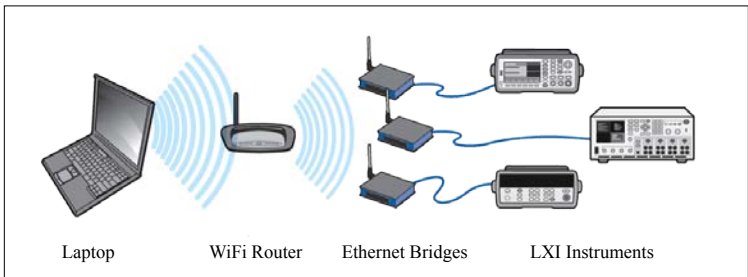


Figure 7 Wireless Test Setup

After the device has powered up and a connection to the LAN has been established, an attempt will be made to obtain an IP address as part of its boot-up process. The LXI specification requires every LXI device have a LAN LED indicator. Once the LED is illuminated ‘green’, this is indication that the LXI device has successfully booted up, obtained an IP address and can be discovered on the network.

## 3.0 Using Your LXI Device

### 3.1 Discovering and Communicating with the Device

LXI instruments are required to have a browser interface that works with all W3C compliant browsers. Use one of the LXI Discovery tools (refer to *section 2.1 Using LXI Discovery Tools*) to automatically access the instrument's Web interface, or type its host name or IP address (refer to your device's documentation to determine the IP address of your device) in the address field of the browser on your PC.

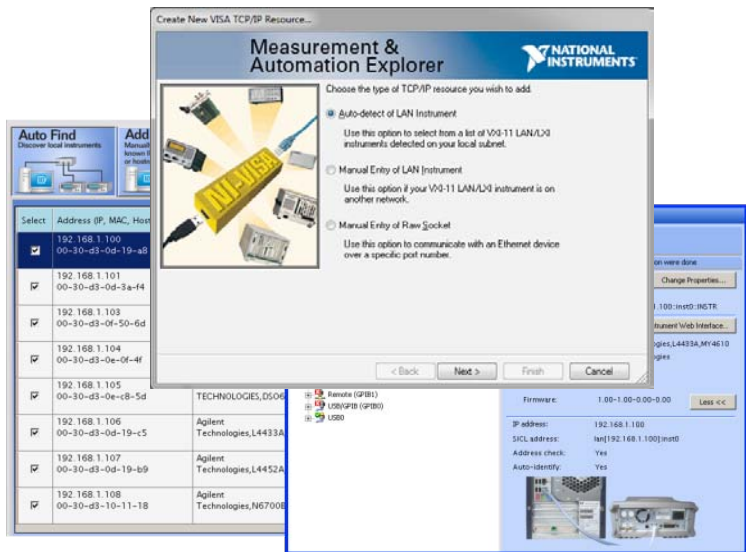


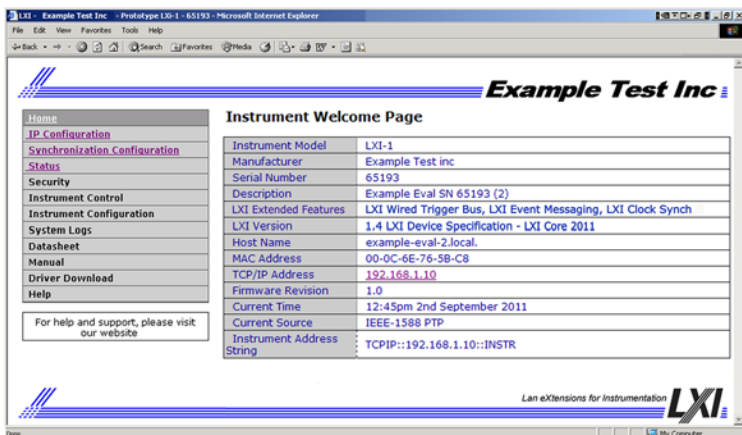
Figure 8 Auto-detect Using LXI Discovery Tools



## 3.2 Web Interface

All LXI devices have a Web interface through which you can configure various instrument settings and control the device to generate and measure signals.

In general, any page(s) that allows a user to change the instrument's settings are password protected. However, the device's default password may be left blank, and in this case, the Web interface may not prompt for a password.



The screenshot shows a web browser window titled "LXI - Example Test Inc. - Prototype LXI-1 - 65193 - Microsoft Internet Explorer". The page features a navigation menu on the left with links for Home, IP Configuration, Synchronization Configuration, Status, Security, Instrument Control, Instrument Configuration, System Logs, Datasheet, Manual, Driver Download, and Help. Below the menu is a text box: "For help and support, please visit our website". The main content area is titled "Instrument Welcome Page" and contains a table with the following information:

Instrument Model	LXI-1
Manufacturer	Example Test inc
Serial Number	65193
Description	Example Eval SN 65193 (2)
LXI Extended Features	LXI Wired Trigger Bus, LXI Event Messaging, LXI Clock Synchron
LXI Version	1.4 LXI Device Specification - LXI Core 2011
Host Name	example-eval-2.local.
MAC Address	00-0C-6E-76-5B-C8
TCP/IP Address	192.168.1.10
Firmware Revision	1.0
Current Time	12:45pm 2nd September 2011
Current Source	IEEE-1588 PTP
Instrument Address String	TCP/IP::192.168.1.10::INSTR

The page footer includes the text "Lan eXtensions for instrumentation" and the LXI logo.

Figure 9 Sample Welcome Page

## 3.3 LAN Configuration

The LAN configuration page contains parameters to configure the LAN settings. The TCP/IP configuration field controls how the IP address for the instrument is assigned. For the manual configuration mode, the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses Dynamic Host Configuration Protocol (DHCP) server or Dynamic Link Local Addressing (Automatic IP) to obtain the instrument's IP address.

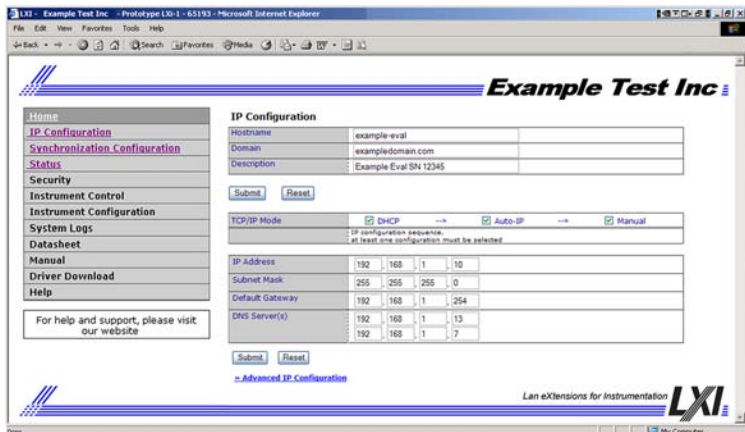


Figure 10 Sample LAN Configuration Page

### 3.4 Optional Sync Configuration

For devices implementing the optional LXI clock synchronization extended function, the sync configuration page allows you to set parameters for IEEE 1588, LXI Events, and the LXI Wired Trigger Bus. You can view the trigger status as well as any errors/warnings from the device's status page.

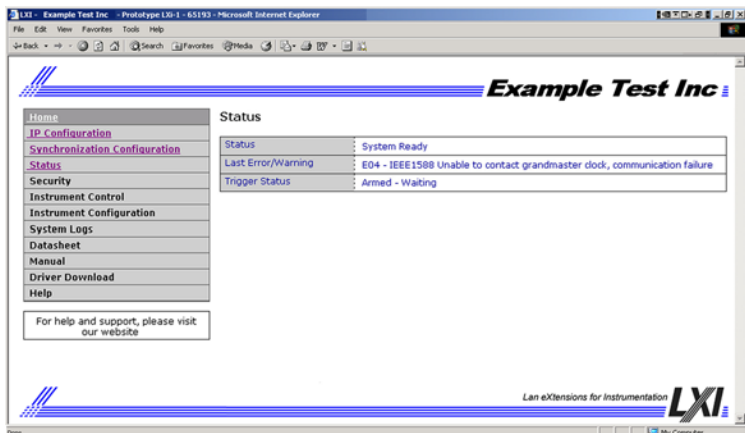


Figure 11 Sample Status Page

### 3.5 Device Control

In addition to configuring the instrument, the Web interface enables you to control your LXI device. For example, you can read values and perform measurements, send output signals, and try out commands. Programmatic control of the device is also possible using its IVI drivers (refer to section 4.0 *Software* for more details).

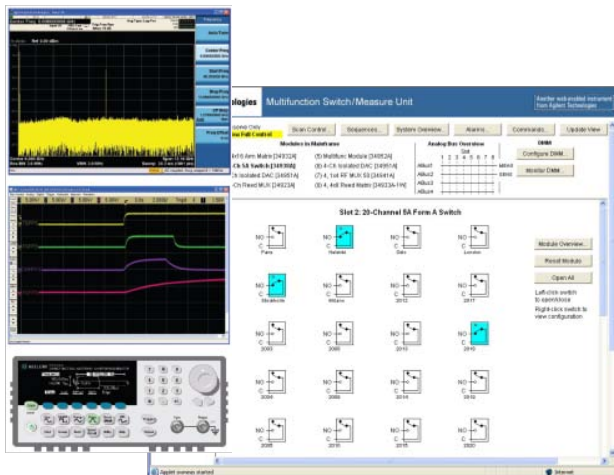


Figure 12 Controlling an LXI Device

## 4.0 Software

### 4.1 Software Overview

As shown in the previous section, you just need a Web browser to communicate with your instrument. However, many users want to programmatically control their instrument from a program that they write. As mentioned in section *1.4 LXI Core Features*, all LXI instruments include an IVI instrument driver. IVI is supported in most major software development environments.

Many LXI instruments communicate via the LAN through one of two protocols, VXI-11 and HiSLIP. These protocols both provide mechanisms to send ASCII commands, such as Standard Commands for Programmable Instrumentation (SCPI), along with other familiar GPIB operations such as Device Clear and Group Execute Trigger. For more information regarding VXI-11, refer to the VXIbus Consortium ([www.vxibus.org](http://www.vxibus.org)). For more information on HiSLIP, refer to the IVI Foundation ([www.ivifoundation.org](http://www.ivifoundation.org)).

To write programs to control LXI instruments that support HiSLIP or VXI-11, you can use the VISA API available at: [www.ivifoundation.org](http://www.ivifoundation.org). VISA implementations and debugging tools for diagnosing network communications problems with LXI devices are available from several vendors.

## ***4.2 IVI Drivers***

All LXI instruments provide an IVI driver. The IVI standards assure you that the drivers can all be installed together and provide some common features and consistency. These common capabilities make it easier to work with instruments from a variety of vendors and reduce the time and effort to develop and maintain system software.

All LXI devices come with some form of IVI instrument driver—IVI-C, IVI-COM, or IVI.Net. These drivers are typically accessible from one of the following locations: the LXI product's Web interface, the distribution disk delivered with the product, or the manufacturer's Web site. IVI drivers can also be found at the IVI Foundation's driver registry Web site at:  
[www.ivifoundation.org/registered\\_drivers/driver\\_registry.aspx](http://www.ivifoundation.org/registered_drivers/driver_registry.aspx).

For assistance with IVI drivers, refer to the Getting Started Guides available at: [www.ivifoundation.org](http://www.ivifoundation.org).

## 5.0 Other Resources

### 5.1 List of Useful Web Sites

LXI Consortium	<a href="http://www.lxistandard.org">www.lxistandard.org</a>
LXI Device Specification 2011, rev. 1.4	<a href="http://www.lxistandard.org/Specifications/Specifications.aspx">www.lxistandard.org/Specifications/Specifications.aspx</a>
LXI Discovery Tool	<a href="http://www.lxistandard.org/Resources/LXIDiscoveryTool.aspx">www.lxistandard.org/Resources/LXIDiscoveryTool.aspx</a>
Guides for Using LXI <ul style="list-style-type: none"><li>• LXI Getting Started Guide</li><li>• Building LXI-Based Test Systems</li><li>• Introducing LXI to Your Network Administrator</li></ul>	<a href="http://www.lxistandard.org/Resources/GuidesForUsingLXI.aspx">www.lxistandard.org/Resources/GuidesForUsingLXI.aspx</a>
LXI Application Articles and Videos	<a href="http://www.lxistandard.org/Resources/">www.lxistandard.org/Resources/</a>
IVI Foundation	<a href="http://www.ivifoundation.org">www.ivifoundation.org</a>
IVI Foundation Driver Registry	<a href="http://www.ivifoundation.org/registered_drivers/driver_registry.aspx">www.ivifoundation.org/registered_drivers/driver_registry.aspx</a>
VXIbus Consortium	<a href="http://www.vxibus.org">www.vxibus.org</a>





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