



Introducing LXI to your Network Administrator

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1 Introduction

Test System Developers and users desire to use LXI Devices (LAN eXtensions for Instrumentation) to build a test and measurement system which successfully connects to the company LAN. The Network Administrator needs to understand how LXI Devices behave when connected to the company LAN.

This document describes how LXI Devices interact with the LAN, so the Network Administrator can maintain LAN security and maximize performance while meeting the requirements of the test and measurement system.

Here is a list of typical issues where users need help when connecting LXI Devices to the company LAN:

- Procedures and requirements for adding new devices to the company LAN
- Test System performance can be affected by LAN broadcast traffic
- Recommended LAN Switches and Routers to support LAN throughput needs of LXI Devices
- Test System may require multi-user access, or it may be desirable to avoid multi-user access
- Test System Developers often need to monitor Test System operation remotely
- Updates and backups for the Test System computer should avoid interrupting running tests
- LXI Devices may require software updates and should not be updated while running tests
- Test System computer may push test results to a company network Database Server

Please Note: *adding an LXI Device to the company LAN would involve the same process as adding a computer to the company LAN. LXI Devices are required to act the same.*

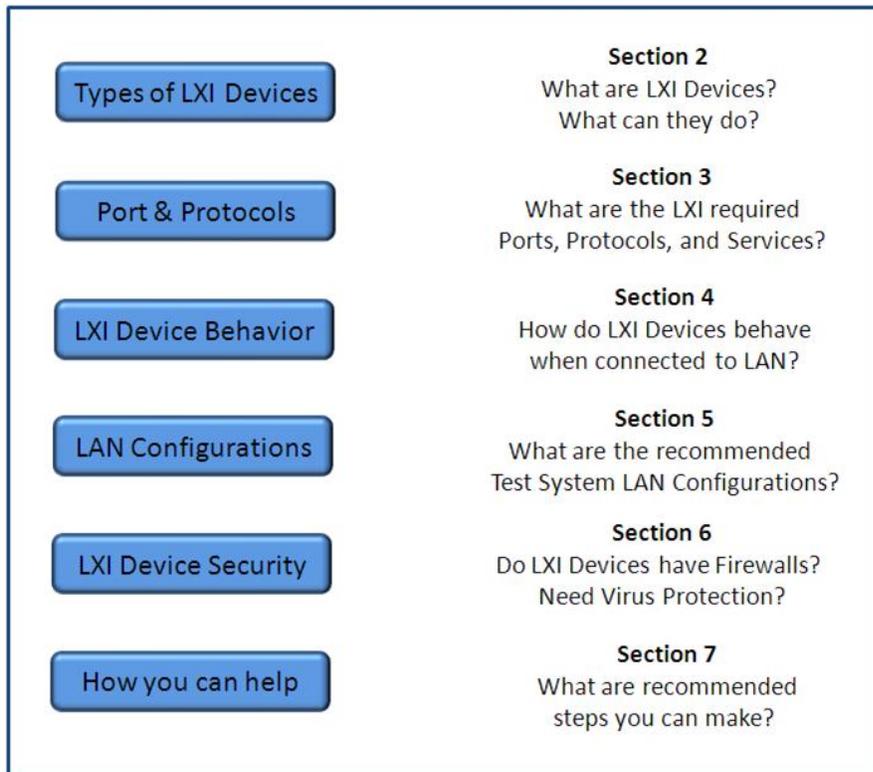


Figure 1.1 Topics covered in this guide.

The LXI Consortium has written two other documents to help users and Test System Developers: ***LXI Getting Started Guide*** and ***Building LXI-based Test Systems***, located on the LXI Consortium Website at [GuidesForUsingLXI](#). These documents will assist them in properly using LXI Devices on the company LAN. However, there are constant references for users to work with the Network Administrator before connecting to the company LAN or using any LAN Device that could compromise network security or performance. Other documents provided at that site: ***Glossary of Networking Terms*** and ***LXI Networking Basics***. These provide a central repository for terminology and typical LAN connectivity basics.

2 Types of LXI Devices

LXI is the standard for Test and Measurement Instruments and provides a consistent and predictable behavior for LXI Devices connecting to the LAN. The LXI Consortium formed in 2004 to bring consistency to LAN operation and configuration for LAN-connected instrumentation. As of May 2013, there are over 2000 LXI conformant devices. Just about every instrument type you can imagine has an LXI conformant offering. Here are a few of the instrument types. There are many more from over 35 vendors of LXI Devices.

Capacitance Meters	Oscilloscopes
Counters	Power Meters
Digitizers	Power Supplies
Digital Multimeters	Signal Sources
LCR Meters	Sound and Vibration Analyzers
Logic Analyzers	Spectrum Analyzers
Network Analyzers	Switches

LXI Core Functionality

LXI Conformant Devices all provide a base or core behavior when connecting to LAN and requiring various Ports, Protocols, and Services over LAN. They must provide a Home Web page for identification and description, and they must provide a LAN Configuration page for setting IP Address mode, IP Address, Subnet Mask, Gateway access, etc. This is all very similar to the configuration of a typical computer with LAN.

LXI Extended Features

Optionally, LXI Devices may provide features such as LXI Time Synchronization (IEEE-1588-2008), LXI Events (peer-to-peer or broadcast), and IPv6 protocol, all of which introduce additional LAN traffic. These Extended Features often require additional LAN Configuration pages on the LXI Device.

3 LXI Ports, Protocols, and Services

LXI conformant devices have a standard set of Ports, Protocols, and Services for LAN operation, but there are also LXI Device-specific Ports, Protocols, and Services. LXI Extended features are optional, and the Home page of the LXI Device lists these extended features, if implemented.

Standard LXI Device Ports, Protocols, and Services			
Protocol/Service	Port	Base Protocol	Notes
mDNS	5353	UDP/TCP	Zero-config protocol for <hostname>.local address resolution; service discovery; Multicast 224.0.0251, FF02::FB
Http	80	TCP	Instrument web pages
ICMPv4		ICMP	Typically enables echo request/respond for ping
ICMPv6		ICMP	Optional - Typically enables echo request/respond for ping, also SLAAC for IPv6 addresses, RDDNS
Arp		Arp	Used to confirm address assignments
DHCPv4	67/68	UDP/TCP	IPv4 address assignment, DNS Server, Dynamic DNS, Gateway
DHCPv6	546/547	UDP/TCP	Optional IPv6 address assignment, DNSv6 Server, IPv6 Gateway
DNS	53	UDP	Naming service
Telnet	23	TCP	Bidirectional interactive text-oriented communication.

LXI Device-specific Ports, Protocols, and Services			
Protocol/Service	Port	Base Protocol	Notes
HiSLIP	4880	TCP	Optional instrument control protocol
VXI-11	111	TCP	Builds upon Sun-RPC and port-mapper.
Scpi-raw	5025	TCP	Optional instrument control protocol
Scpi-telnet	5024	TCP	Optional instrument control protocol over Telnet
LXI-eventsvc	5044	UDP/ TCP	Optional LXI Event support for instrument triggering; multicast 224.0.23.159, FF02::138
Ptp-event	319	UDP/ TCP	Optional LXI Profile IEEE 1588 Precision Time Protocol; multicast 224.0.1.129, FF02::181
Ptp-general	320	UDP/ TCP	Optional LXI Profile IEEE 1588 Precision Time Protocol; multicast 224.0.1.129, FF02::181

4 LXI Device Behavior on the LAN

An LXI Device needs an IP Address just as computers do when connected to the LAN. They support an Automatic or DHCP IP Address mode, and a Static IP Address mode. The behavior of the LXI Device follows very closely the model of a computer connected to the LAN.

Automatic or DHCP IP Address Mode

- When connecting to the LAN, if a DHCP Server is available, an LXI Device acquires its IP Address, Subnet Mask, Gateway, DNS Server, etc. from the DHCP Server
- If the DHCP Server does not respond, the LXI Device drops into the AutoIP or Link Local Addressing mode. For IPv4, the address range used is **169.254.x.x**, same as the computer.
- The LXI Device sets its LAN Status to “non-fault” if successful in acquiring an IP Address

Static IP Address Mode

- When connecting to the LAN, the LXI Device broadcasts its desired IP Address. If no other device responds as using that IP Address, the LXI Device formally connects to the LAN.
- If another LAN Device is using that IP Address, the LXI Device disengages from the LAN and sets its LAN Status to a fault condition.

LAN Status

LXI Devices must have a LAN Status indicator that shows the health of the LAN connection. LAN Status indicators must be on the Front Panel of the LXI Device, but they could be LEDs with labels or embedded in the Display menu under a Utility or System key. Figure 4.1 illustrates three examples of LAN Status fault conditions where the LXI Device could not acquire an IP Address. LXI Devices with Displays typically show an IP Address of **0.0.0.0** with the fault indicator.

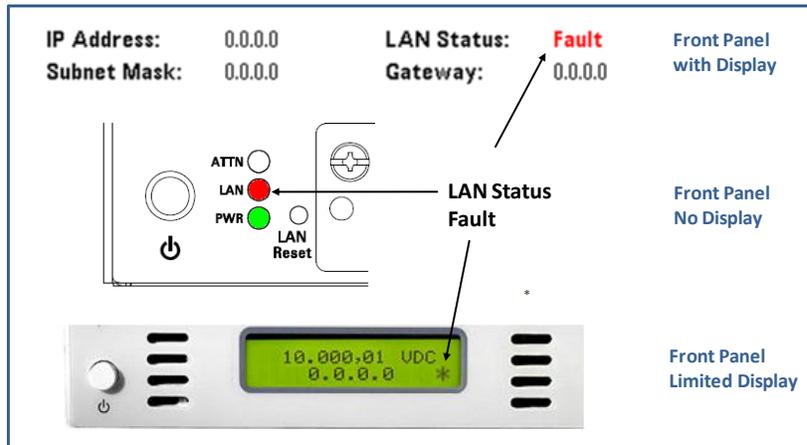


Figure 4.1 LAN Status Indicators

LAN Reset for LXI Device

An LXI Device has a required feature called the LAN Configuration Initialize (LCI or LAN Reset) which defaults to the Automatic IP Address or DHCP mode and restarts its LAN operation. This usually corrects problems associated with a Static IP Address assignment that conflicts with the existing local subnet. The LAN Reset is either a recessed button on the LXI Device or a menu

entry in the Utility or System menus, as shown in Figure 4.2. You may need a paper clip to access the recessed button.

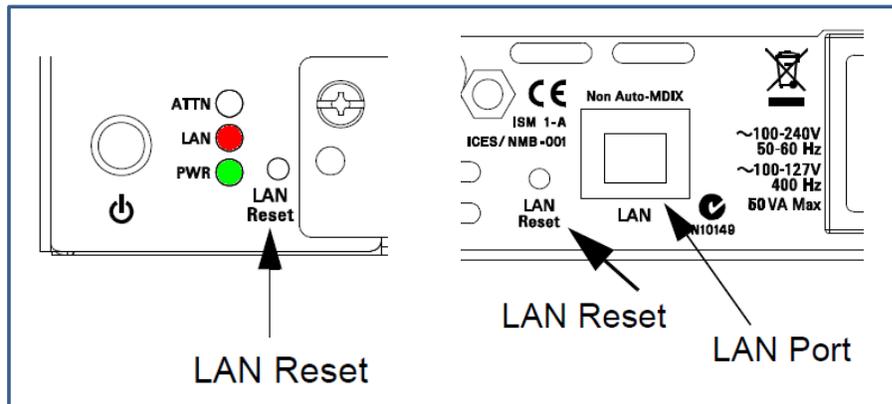


Figure 4.2 LAN Reset (LCI mechanism)

LAN Configuration

Every LXI Device is required to support a LAN Configuration page accessible from the Home page of the LXI Device. This LAN Configuration page provides a way to configure the LAN settings of the LXI Device. An LXI Device’s LAN Configuration is very similar to a computer’s LAN Configuration page. Figure 4.3 illustrates the analogous configuration between a computer and LXI Device LAN Configuration pages.

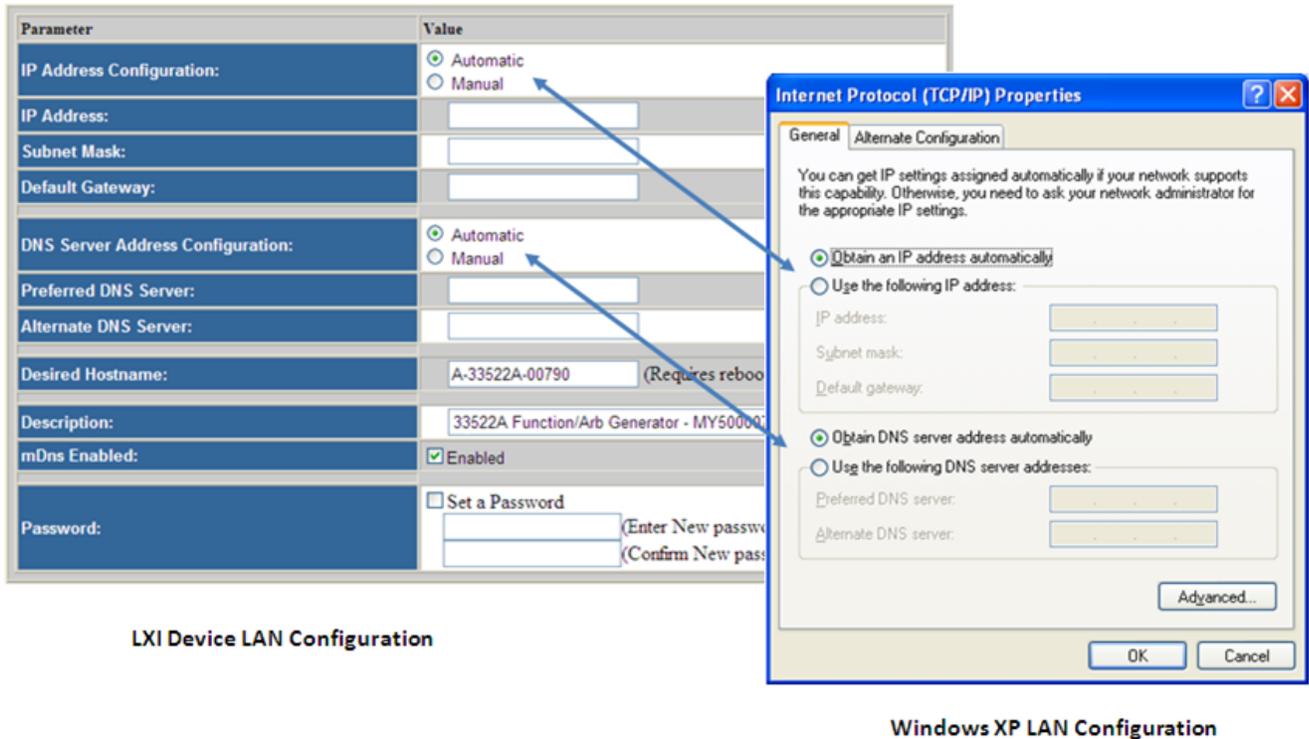


Figure 4.3 LAN Configuration

LAN Discovery

LXI Devices must have several features to assist finding their IP Address on the LAN. If the LXI Device has a Front Panel Display, the IP Address may be available from the Display. However, some LXI Devices do not have a display. The LXI Consortium provides the *LXI Discovery Tool* at [GuidesForUsingLXI](http://www.lxistandard.org/GuidesForUsingLXI) to find the IP Address of devices meeting the LXI Specification. This tool discovers IP Addresses of LXI Devices “visible” to the computer’s subnet using the **mDNS** and **VXI-11** protocols, which are described further in *Section 2 LXI Ports, Protocols, and Services*. For more information on LAN discovery, please access the LXI Specification at the following location:

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

The Section *LAN Discovery and Identification* in the LXI Specification covers the discovery requirements for LXI Devices.

The VISA Library (Virtual Instrument Software Architecture) is available from several vendors and may provide an LXI discovery tool. Test System Developers often install VISA on their Test System computer for instrument control.

After determining the LXI Device’s IP Address from the Front Panel or discovery tool, use a Web browser to access the Home page and the LAN Configuration page.

LAN Operation and Performance

Most LXI devices support 100Mbit Full Duplex operation, but many support Gigabit LAN. Some LXI Devices require large amounts of data transferred from the computer to set up signals applied to a DUT (Device-Under-Test), while other devices make 1000’s of high-speed measurements for transfer back to the computer as quickly as possible.

The majority of instruments interact in short bursts of ASCII or binary representing setup and data. Digitizers and Oscilloscopes are examples of devices that may transfer millions of readings per second, with each reading in a 2 to 8 byte format. However, they typically do not stream data continuously across the LAN.

Most test systems involve a sequence of programming steps for connecting test signals through an analog switch between a signal source, the DUT, and the measurement instruments. It is typically a sequential programming model where the computer configures the instruments for each test using short bursts of commands and data. Do this...now do that...with hundreds of tests that could last for hours.

5 Recommended LXI Test System LAN Configurations

The LXI Consortium members have recommended six LAN Configurations for LXI-based Test Systems. Each of these configurations in the following sections provides a short description, the LAN interconnections, and a list of Benefits and Cautions. The Test System Developer will choose one of these LAN Configurations (or a variation) for their Test System, and they will likely need help from the Network Administrator in the following areas:

- Help in acquiring IP Addresses from the LAN DHCP Server, if special registration required
- Permission to connect Routers to the company LAN for private subnet Test System
- Permission to use and help to configure wireless LAN for LXI Devices
- Help configuring any required IT access to Test System computer
- Help setting up remote-login to Test System computer
- Help scheduling backups and software updates that do not interrupt running tests
- Help setting up security for LXI Devices using commercial operating systems

Figure 5.1 shows an overview of the first four recommended Test System LAN Configurations. The remaining two LAN Configurations are a subset of these and discussed later.

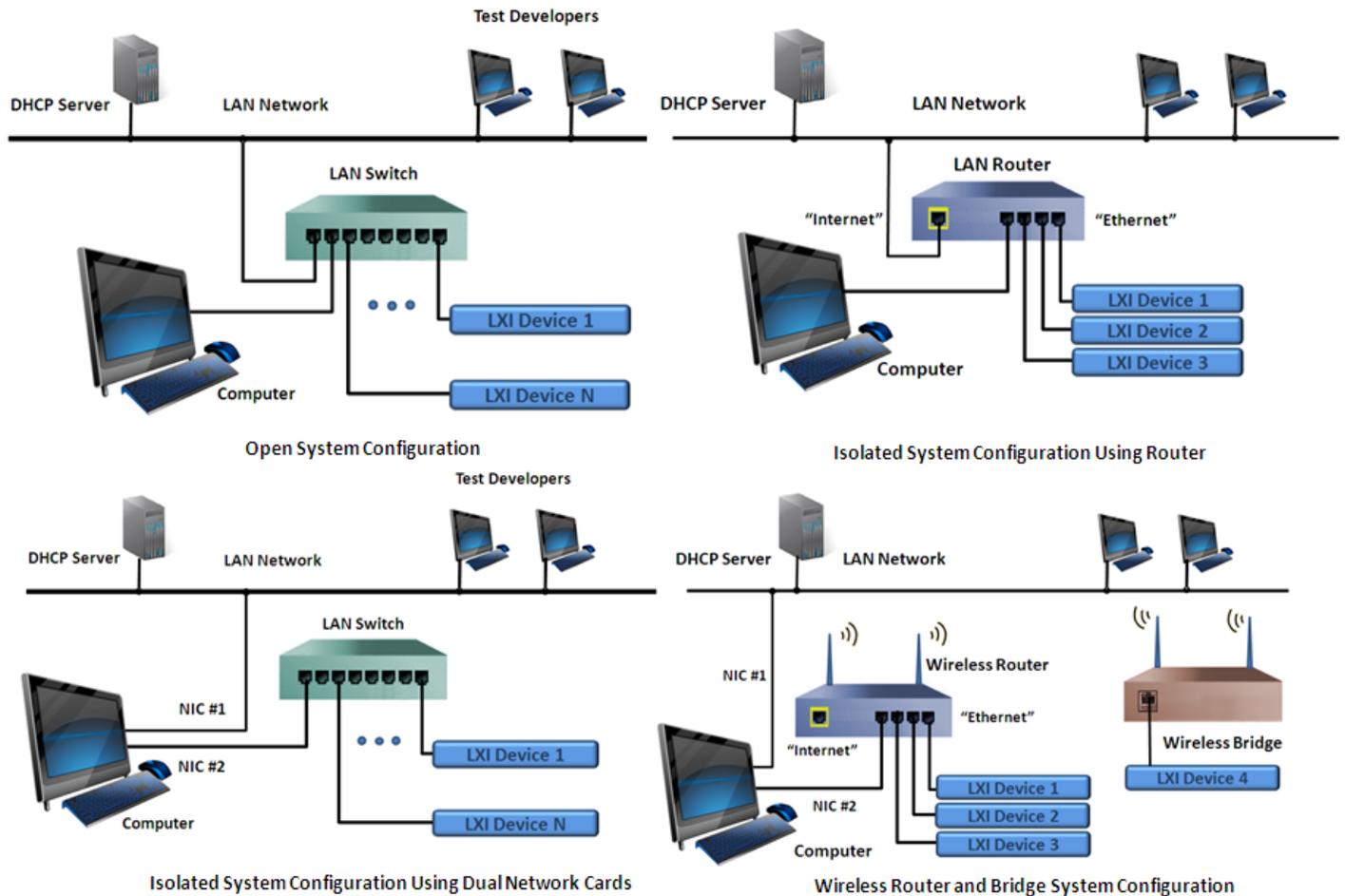
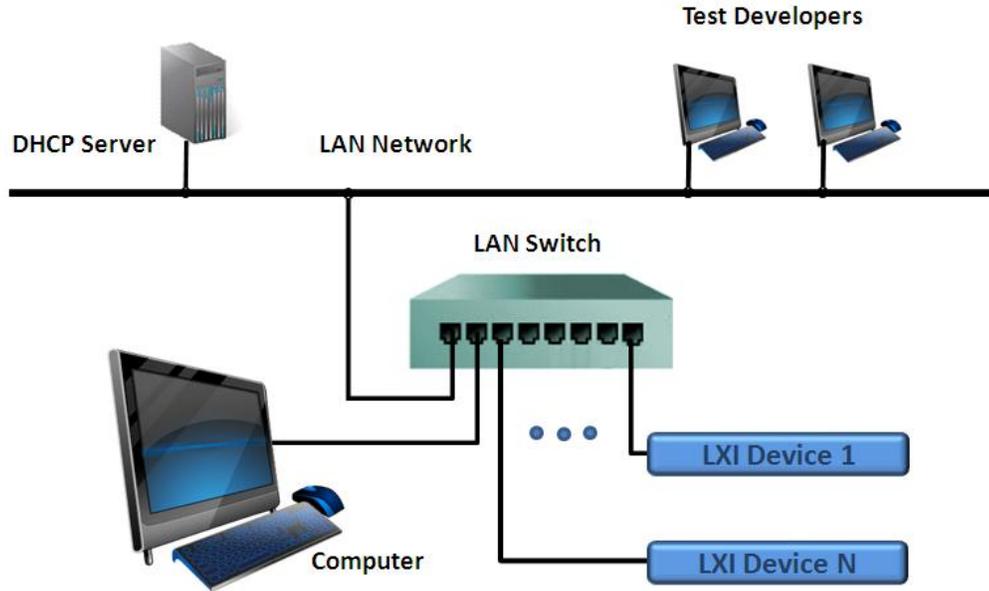


Figure 5.1 Summary of recommended Test System LAN Configurations

5.1 Open System Configuration Using Switch

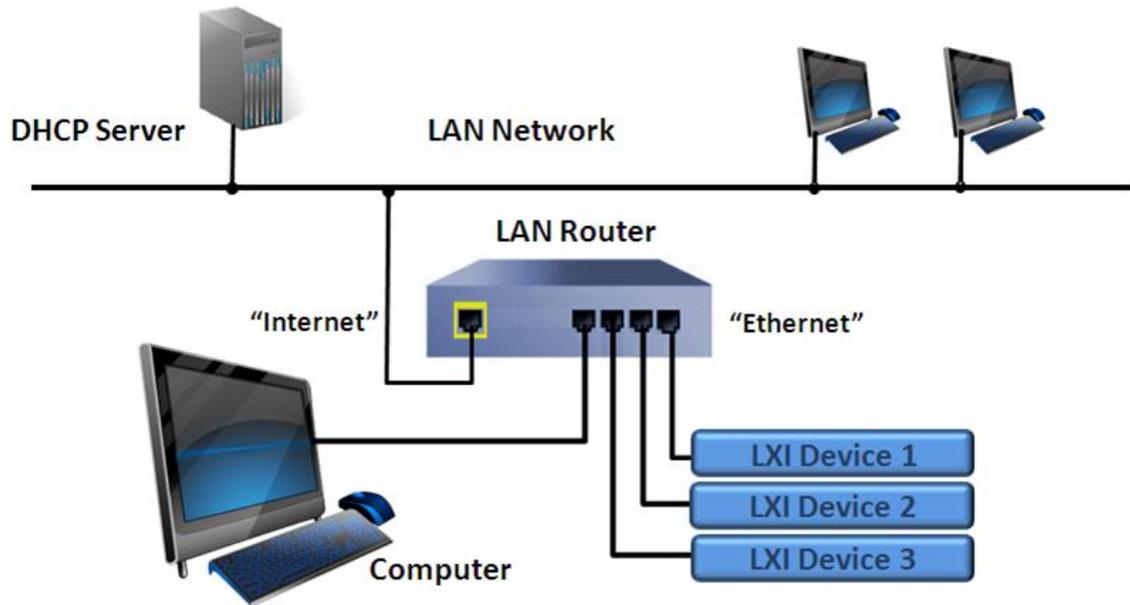
This configuration provides open access of the Test System computer and LXI Devices to all users on the LAN. It permits multiple users to develop tests using the Test System. All LXI Devices acquire an IP Address from the company DHCP Server.



Benefits	<ul style="list-style-type: none"> • Test System is accessible by anyone on the LAN Network • Users can develop, troubleshoot, and execute tests from their own computer instead of only using the Test System computer • Users can monitor activity of LXI Device using a Web browser • Network Administrator has complete access to Test System computer for security updates and backup
Cautions	<ul style="list-style-type: none"> • Traffic on LAN Network affects performance of Test System. • Active tests may be interrupted by other users accessing the Test System computer or the LXI Devices, including accessing their Web pages • Each device in the Test System requires IP Address from company DHCP Server • IP Addresses can change with re-configuration of DHCP Server • Security updates and backups may affect Test System performance and should be coordinated to times when the Test System is not in use • LXI Devices with a commercial operating system like Windows on their embedded computer may also require coordinated updates to avoid interrupting tests

5.2 Isolated System Configuration Using Router

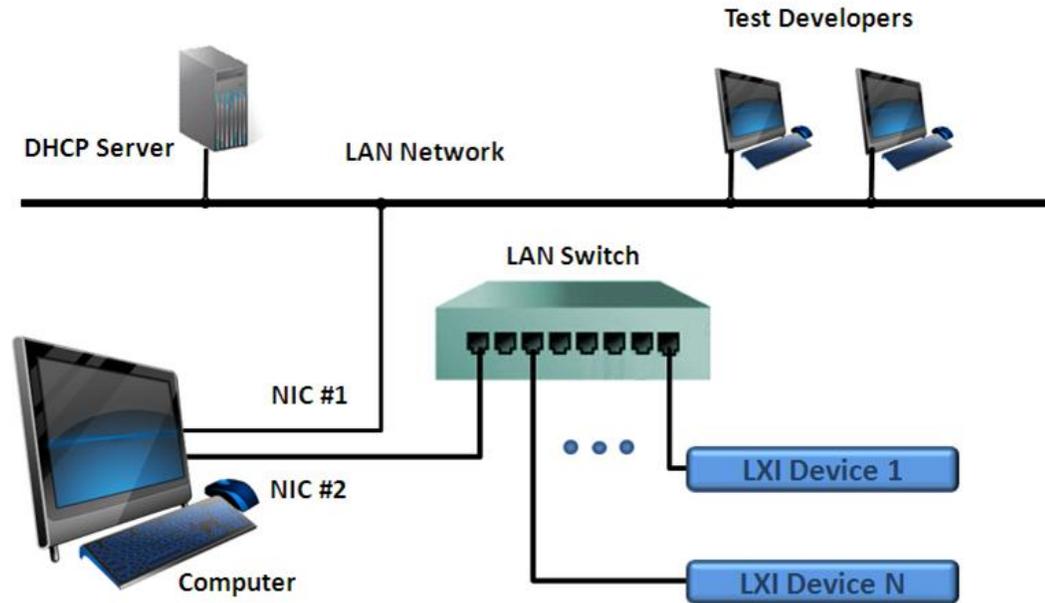
This configuration hides the Test System computer and LXI Devices from the LAN. It isolates the Test System from the LAN to avoid performance degradation or interruption of tests. Only the Router acquires an IP Address from the company DHCP Server.



<p>Benefits</p>	<ul style="list-style-type: none"> • Test System and computer are isolated from LAN users and traffic which maintains performance of Test System with no interruption of tests • Test System computer can maintain a fixed operating system revision that is not changed automatically by Network Administrator software • Single IP Address required from company DHCP Server while computer and LXI Devices receive their IP Address from the built-in DHCP Server of Router • Can configure Router to use MAC Address Cloning, enable Ping, and pass port requests to the computer to make it appear still on the LAN. • Router configurable to allow remote-login from external users
<p>Cautions</p>	<ul style="list-style-type: none"> • Network Administrator may lose access to Test System without special configuration of Router. • Loss of remote-login access by users without special configuration of Router • Ethernet port on Router should never be connected to LAN Network • The company DHCP Server may not allow Router connected to LAN Network and will not assign IP Address • Loss of Domain Name Service (DNS) for using Hostnames on local network

5.3 Isolated System Configuration Using Dual Network Cards

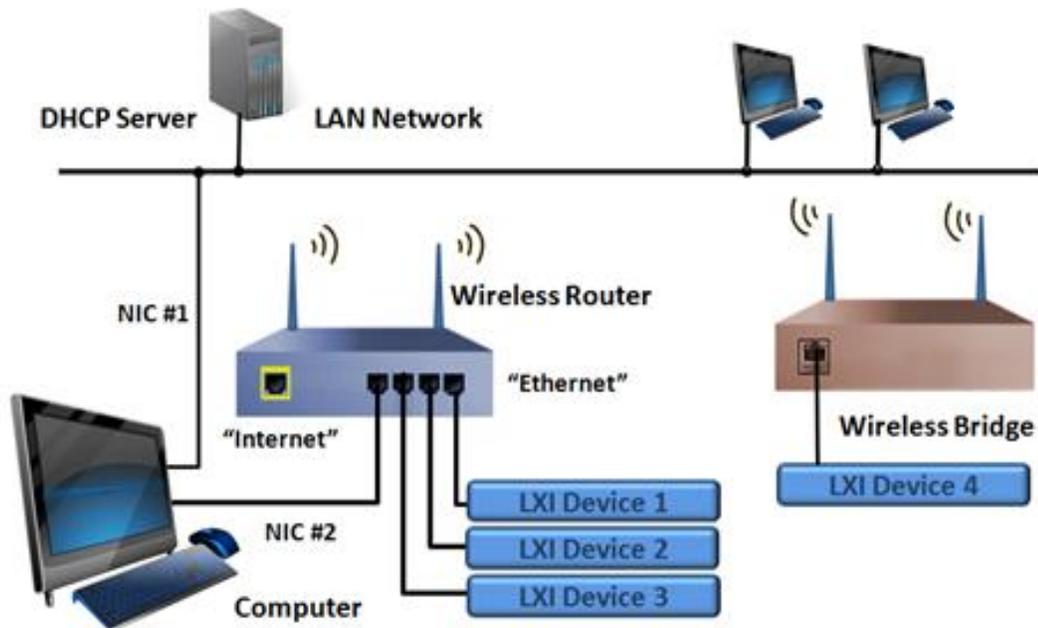
This configuration hides the Test System LXI Devices from the LAN but leaves the computer accessible. Test Developers can remote-login and develop tests, and LXI Devices are not affected by interrupts from LAN traffic.



Benefits	<ul style="list-style-type: none"> • LAN Interface NIC #1 of computer connected to LAN Network, so company DHCP Server does not see LXI Devices on NIC #2. • Users can remote-login to Test System computer to control LXI Devices • Network Administrator has access to computer for security updates and backup • LXI Devices isolated from LAN users and broadcast traffic • Single IP Address required from DHCP Server for computer. • LXI Devices can use static IP Address or AutoIP Address or can run software DHCP Server installed for NIC #2
Cautions	<ul style="list-style-type: none"> • Loss of Domain Name Service (DNS) for using Hostnames on local network • Viruses introduced into LXI Devices can infect computer through NIC #2. Computer must have way of cleaning viruses from NIC #2 subnet • Some LXI Devices may need computer support between NIC's, such as Internet Connection Sharing (ICS), to access the Internet through NIC #1.

5.4 Wireless Router and Bridge Configuration

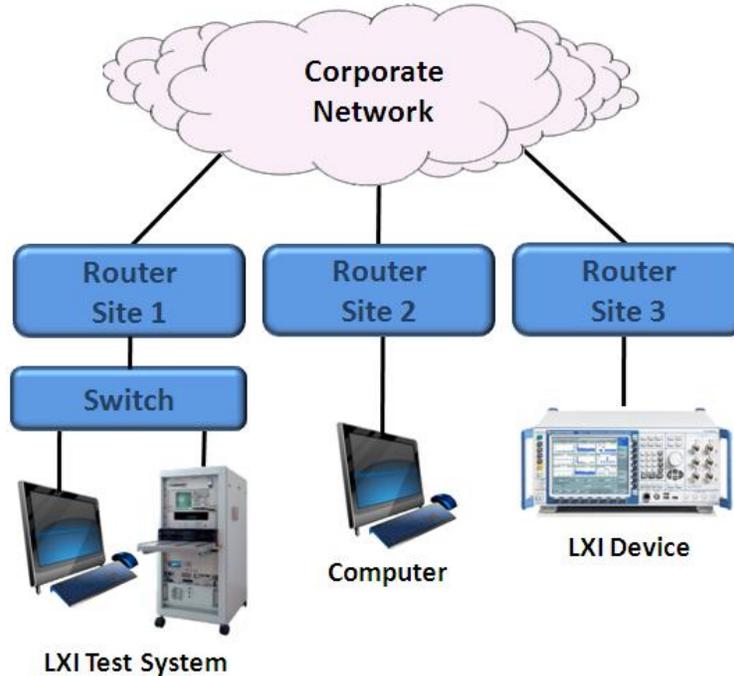
This configuration demonstrates how to overcome environmental hazards, wiring difficulties, or distance limitations while providing a reasonable method to maintain LAN security using wireless communication in combination with Dual NIC interfaces. The Dual NIC provides an extra level of isolation to block wireless access to LAN.



<p>Benefits</p>	<ul style="list-style-type: none"> • All the benefits of <i>Isolated System Configuration Using Router</i> • Wireless WPA2 security and no Router connection to LAN Network offer good security • Remote LXI Device can be located on moving structure, in toxic/hazardous environment, differing ground potentials, at a distance from Test System, etc. • Significant cost savings when avoiding long-distance wiring and complexities for the above listed use cases.
<p>Cautions</p>	<ul style="list-style-type: none"> • All the cautions of <i>Isolated System Configuration Using Router</i> • Wireless configurations may not be allowed or possible in some environments • Wireless connections share bandwidth, which can degrade performance.

5.5 Accessing LXI Devices Remotely via Company Intranet

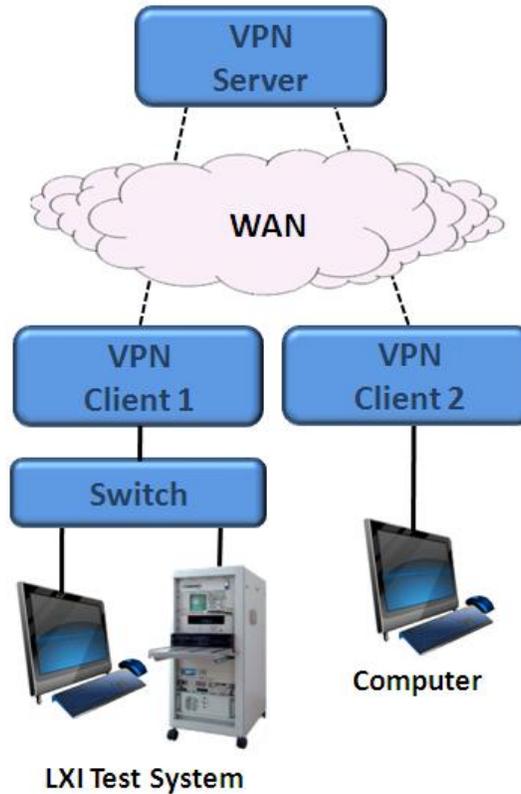
This configuration permits users to access equipment at different company sites. Users at one site can develop, troubleshoot, and monitor Test Systems installed at another site, even sites in different parts of the world. Users must know the remote LXI Device IP address in order to access it and may need help in determining these IP addresses.



<p>Benefits</p>	<ul style="list-style-type: none"> • An extension of benefits for <i>Open System Configuration Using Switch</i> where users are now at other physical sites within the company intranet • All communication exists behind the company Firewall • Engineering and Test Development may be on one site and Production at a different site. Developers can monitor and troubleshoot Test System without traveling to remote site. Users need only communicate IP Addresses to each other • Training and consulting on complex instrumentation can occur remotely • Antenna testing works for this configuration since the Test System signal source can transmit through air with the receiver controlled through intranet at remote site
<p>Cautions</p>	<ul style="list-style-type: none"> • Extension of cautions for <i>Open System Configuration Using Switch</i> • Unless a virtual private LAN (VPN) implemented, users at different sites must inform each other of LAN IP Addresses, since the <i>LXI Discovery Tool</i> cannot discover LXI Devices on different subnets • LAN performance limited by network interconnect speeds between source and destination

5.6 Accessing LXI Devices Remotely via VPN Connections

This configuration permits a user to access the Test System from anywhere in the world using the Wide Area Network. A user can develop, troubleshoot, and monitor a Test System from outside the company intranet. This is a typical configuration for employees accessing the company LAN while at home or traveling.



<p>Benefits</p>	<ul style="list-style-type: none"> • An extension of benefits for <i>Open System Configuration Using Switch</i> where a single user can now access the Test System from anywhere • VPN (Virtual Private Network) extends the company intranet across the Internet so remote user is virtually on the company LAN. User can access Test System directly from remote computer or can remote-login to Test System computer. Remote-login to Test System computer provides user ability to run test programs at speed of Test System. • Provides developers access to Test System while traveling or from home
<p>Cautions</p>	<ul style="list-style-type: none"> • This configuration requires extensive support from the Network Administrator but is typical with today's workforce working remotely. • Running test programs on remote computer could be very slow and cause timeouts and test failures

6 LXI Device Security

Most LXI Devices use an embedded operating system that does not pose a security threat since they do not access email or surf the Web. These same devices might support removable USB drives that could potentially infect the LXI Device if the embedded operating system allows running software on that USB device. However, these LXI Devices boot from a fixed, non-infected operating system image, so viruses are temporary.

There are some LXI Devices with embedded computers using commercial operating systems requiring virus protection software. These devices would be susceptible to the same security attacks as a company computer, except the devices typically would not be used for email or surfing the Web.

LXI Devices with these commercial operating systems often ship with Firewall protection enabled, and there should be recommendations provided for installing virus protection software to address security threats. In addition, many LXI Devices with USB Drives ship with Auto-run disabled when USB drives insert, and the installed virus protection software scans any inserted USB drives.

The LXI Consortium provides a document called *Malware Protection White Paper* under the IT Topics tab and found at <http://www.lxistandard.org/Resources/Default.aspx>. This paper gives examples of products with commercial operating systems requiring virus protection. Please refer to that document for further details on recommended methods of protecting such a device.

Security for Isolated System Configuration Using Router

This configuration isolates the computer from the LAN and Network Administrator update software. If that software pushes updates to the computer rather than the computer pulling updates, this requires a change in Router configuration. The guide *Building LXI-based Test Systems* discusses several possibilities requiring Network Administrator assistance. It discusses the concept of making the Router appear to be the computer by using MAC Address Cloning and then using Port Forwarding or DMZ (Demilitarized Zone) along with enabling Ping to allow continued updates to the computer. This essentially makes the computer appear directly connected to the LAN. This configuration also allows LAN users to remote-login to the computer for test development

Here is a summary of important considerations:

- In general, updates to computer or LXI Devices should be done during down-time of the Test System to avoid interrupting tests
- LXI Devices requiring virus protection usually pull virus and operating system updates and need access to a Gateway to the Internet.
- LXI Devices should never have updates pushed to them without coordinating with the Test System Developer to avoid interruption of device operation
- Avoid upgrading an LXI Device with a commercial operating system (e.g. Windows XP to Windows 7). Consult with LXI Device manufacturer for upgrade.
- LXI Devices with commercial operating systems may have a detachable keyboard and mouse, but these devices typically do not browse the internet or access email
- For the Dual NIC configuration - LXI Devices with commercial operating systems moved to another subnet might be more susceptible to a virus infection. They might bring this virus back with them when returning to the Test System.

7 Recommended steps for the Network Administrator

The six recommended LAN Configurations include Benefits and Cautions, which should provide good insight into the challenges presented when connecting these configurations to the company LAN. The Network Administrator can use this information in understanding how to assist the Test System Developer plan, configure, and maintain the Test System LAN Configuration. This section provides a summary of the actions the Network Administrator can take in assisting the Test System Developer:

Fine-tune LAN Configuration. Review the recommended LAN Configurations with the Test System Developer and discuss alternatives based upon experience and knowledge of high performance LAN configurations and computer security standards. For example, a Wireless Router and Bridge may appear to be the only solution in some situations, but there may be other alternatives providing better security.

Recommend and Help Configure Equipment. Recommend approved Routers, Switches, NIC interfaces, Wireless devices, etc., which meet company standards and the performance needs of the LXI Devices. The document *Building LXI-based Test Systems*, provided by the LXI Consortium at [GuidesForUsingLXI](#), illustrates methods of configuring Routers for MAC Address Cloning, Ping, and Port Forwarding or DMZ. It also discusses using Internet Connection Sharing on Dual NIC configurations. There may be preferred methods or preconfigured equipment for these configurations.

Recommend Security Methods. With this document, the Network Administrator should have a good idea of the LAN Configurations, what an LXI Device is, and how it behaves on the LAN. The Network Administrator can help the test system developer secure their Test System while meeting company security policies. In particular, the Test System Developer may need help in determining how to keep the test system computer and LXI devices up-to-date on operating system patches and virus definitions during down times for the Test System.

Test System Computer Backup. During development of products, it is often important that daily regression tests execute. Production Test Systems must maintain uptime to avoid delays in product delivery. These computers must have both image and regular backups to minimize downtime. These backups must be coordinated with the Test System Developer to avoid interruption of tests.

Remote Access of Test System. Gaining access to the Test System computer in the Open System Configuration is relatively straightforward to some but not everyone. A bigger challenge is allowing this in the *Isolated System Configuration Using Router*. This requires configuration of the Router for remote-login and other services. It may be simpler to supply a pre-configured Router that makes the Test System computer accessible.