



LXI Getting Started Guide

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1 Introduction

This document helps you connect to your first LXI Device (**L**AN **eX**tensions for **I**nstrumentation). It will focus on the most likely scenario of a simple wired connection with everything working as expected, and then it will help you understand how to add the LXI Device to your work or company LAN (Local Area Network). You will discover the device's IP address, bring up its Web page, learn how to access its LAN Configuration pages, and have an understanding of where to go next to learn how to program LXI Devices and build an LXI-based Test System. Figure 1.1 illustrates the flow and content of this document.

A key component of this document is the *LXI Discovery Tool*, located on the LXI Consortium Web site at: [GuidesForUsingLXI](#). This is also the location of other documents such as the *LXI Primer*, *Building LXI-based Test Systems*, and *Introducing LXI to your Network Administrator*, documents described later. In addition to these, you will find documents such as a *Glossary of Networking Terms* and *LXI Networking Basics*, which helps in understanding terminology and basic LAN concepts found in this document.

Appendix A. Troubleshooting will assist you if problems arise during connect and discovery of your LXI Device. *Appendix B. What LXI Conformance Means* provides insight into the behavior and compatibility of LXI Devices enforced by the LXI Standard. *Appendix C. Additional Capabilities of LXI Devices* provides a look at the various features, functions, and uses of LXI Devices.

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.*

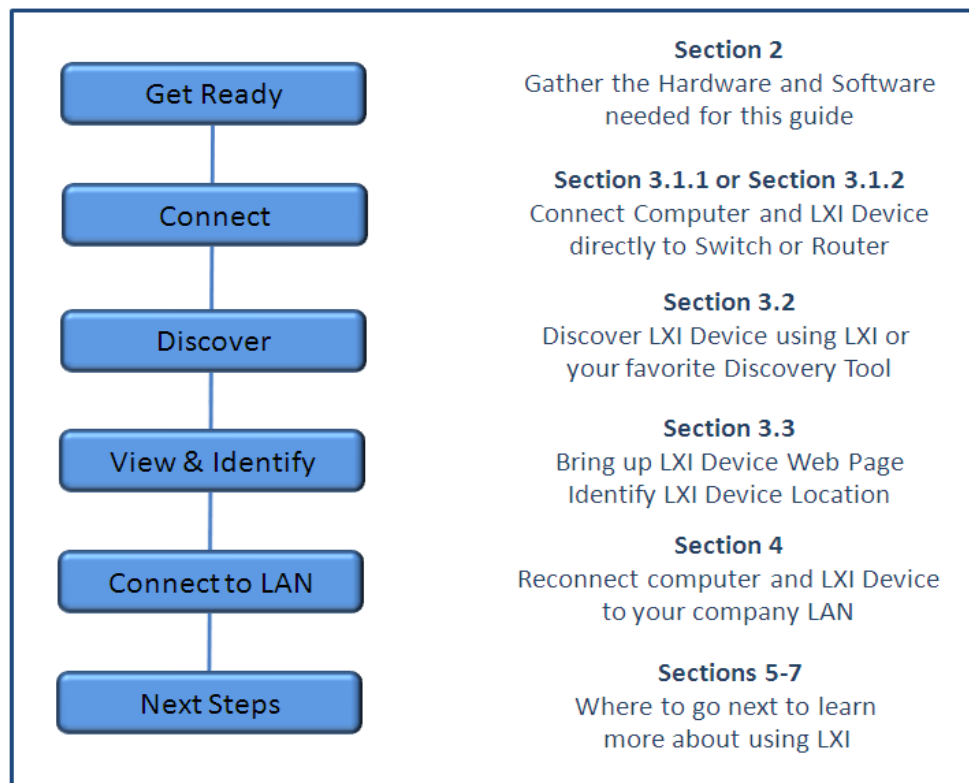


Figure 1.1 Flow and Content of the *LXI Getting Started Guide*

2 What you need to get started

LXI Devices have the unique aspect of not requiring any device drivers for connection and bringing up their Web pages. If you have a Web Browser, you can access the LXI Device Web pages. Many LXI Devices permit complete control of the device from the Web pages and is often much easier than controlling from the Front Panel.

The Web Browser needs an IP (Internet Protocol) Address or Hostname entered into its URL (Universal Resource Locator) to access the LXI Device. The **LXI Consortium** has produced an **LXI Discovery Tool** to assist you in determining the IP Address of any LXI Device. See below for a list of required software and hardware for using this guide:

Hardware:

- Computer with active LAN port – RJ45 connector
- LAN Switch or Router
- Three LAN cables
- LXI Device

Software:

- **LXI Discovery Tool** – an LXI Consortium digitally signed application
- Apple’s Bonjour Print Services for Windows v2.0.2 or later

The **LXI Discovery Tool**, located at [GuidesForUsingLXI](#), discovers LXI Devices on your LAN subnet, the place where your computer and LXI Device can “see” each other. The tool can discover LXI Devices, because it understands the services and protocols required by the LXI specification.

Since programming LXI Devices typically requires the VISA Library (Virtual Instrument Software Architecture) for communication, you may already have Agilent, National Instruments, or Tektronix VISA I/O Library installed on your computer. If so, each of those software packages already includes a discovery and configuration tool. **Agilent Connection Expert**, **NI MAX**, and **TekVISA Configuration** are the associated discovery and configuration tools. Refer to their Help documentation for more information on your particular installation to learn more.

For the purposes of this document, the **LXI Discovery Tool** provides the only tool needed to discover and communicate with your LXI Device. It will not interfere with the VISA Library software you may already have installed.

Additional Resources Recommended

This guide will provide the method of connecting to the LXI Device. All LXI Devices must connect according to the LXI Standard. Once connected, LXI Devices have the freedom to implement such things as LAN Configuration, Device Control, layout, colors, etc. in a manner that is consistent with their company themes and the needs for the particular device. Please have the LXI Device’s documentation available to assist you in the specific LAN Configuration information for your particular device. This Getting Started Guide focuses on the Connection, Discover, View, and Identify, which are all common for LXI Conformant devices.

Access the LXI Discovery Tool Installation Instructions at [GuidesForUsingLXI](#) and complete the installation before proceeding.

3 Connecting the LXI Device and your Computer

Let us assume you only have a single LAN connection in your office. This configuration would look similar to Figure 3.1. If you have already installed a LAN Switch or Router in your office, then that device connects to your company's LAN, and your computer and other LAN devices will connect to the LAN Switch or Router.

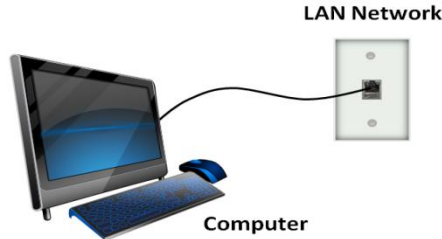


Figure 3.1 Office Computer Connected to company LAN

There can be a wide range of company policies related to connecting a new device to your company's LAN. Because of this likely possibility, this section will focus only on the connection between your computer and the LXI Device. In doing so, you will be asked to disconnect the computer from your company's LAN. This means you will lose access to the company's connection to the Internet, email, etc. Therefore, please make sure you have downloaded and installed the *LXI Discovery Tool* and *Bonjour Print Service* according to the instructions in *Section 2* prior to this step.

There are two basic configurations recommended: the *Open System Configuration* using a LAN Switch and the *Isolated System Configuration* using a LAN Router. Figure 3.2 shows a summary of the two configurations. The *Open System Configuration* gives others on your company LAN access to your LXI Device, and the *Isolated System Configuration* will block access to your LXI Device. Notice we begin disconnected from the company LAN— illustrated by the **X** through the LAN cable to the company LAN.

This section will now walk through the key steps of *Connect, Discover, View, and Identify*. Whether your configuration is through the LAN Switch or Router, you will be able to discover any LXI Devices connected to this isolated subnet. The *LXI Discovery Tool* identifies the IP (Internet Protocol) address of LXI Devices and allows you to bring up its Web page using your computer's Web browser.

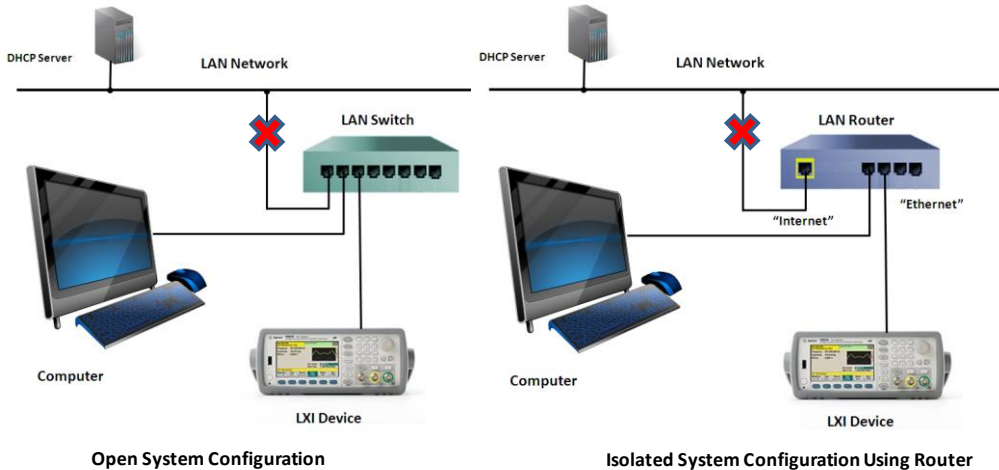


Figure 3.2 Open and Isolated System Configurations

3.1 Connect

Choose the configuration using a LAN Switch or a LAN Router, whichever is deployed or desired in your office. Either configuration will have LAN ports for connecting LAN devices, but each configuration operates differently with respect to the company LAN. If you want to know more about using the LAN Switch or Router, refer to the document *LXI Networking Basics*.

Connecting through a LAN Switch

This is the most likely configuration if you want other users in your company to access your LXI Device. Each office has a single LAN port connecting to the company network via a commercial LAN Switch somewhere in the building that groups offices into a subnet. Every LAN Device on that subnet can “see” every other LAN Device. To connect more LAN devices in your office to the LAN, you can provide an 8-port or larger LAN Switch. Refer to the document *LXI Networking Basics* for more information about the capabilities of a LAN Switch.

Referred to as an *Open System Configuration*, the use of the LAN Switch allows each office to access each other’s computers, printers, etc. Connect your computer and LXI Device to the LAN Switch, according to Figure 3.3. Do NOT connect the LAN Switch to the company LAN at this time. *Section 4, Connecting to the Company LAN* will discuss the steps needed to make that transition.

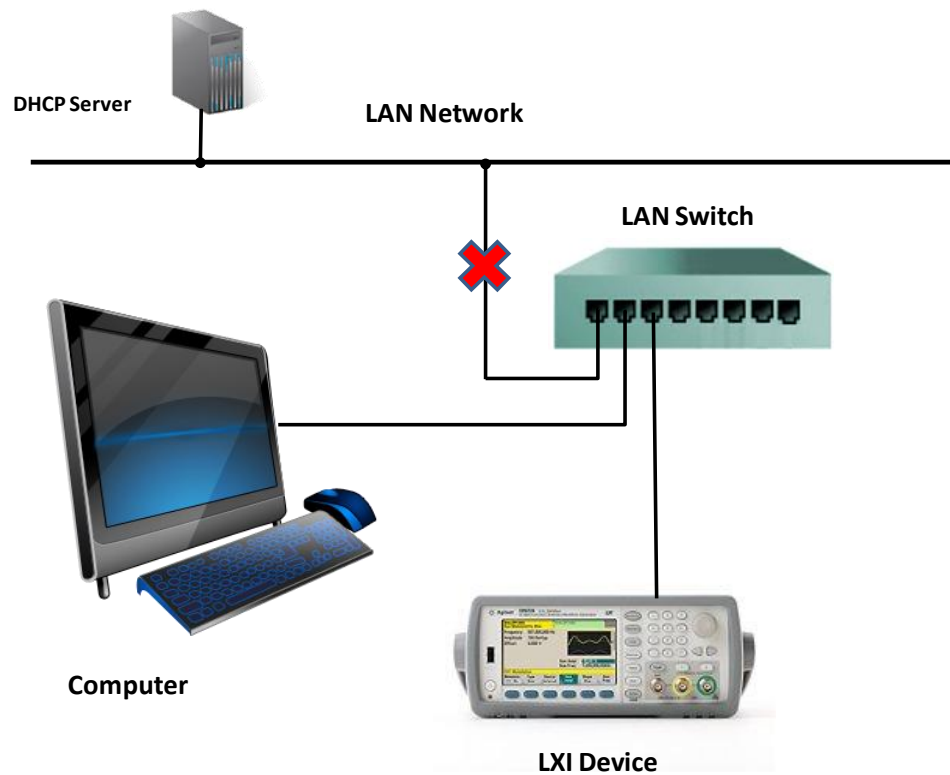


Figure 3.3 *Open System Configuration* using a LAN Switch

Connecting through a LAN Router

This configuration allows isolating your computer and LXI Device from others on your company LAN. Each office has a single LAN port connecting to the company network via a commercial LAN Switch somewhere in the building that groups offices into a subnet. Every LAN Device on that subnet can “see” every other LAN Device.

To isolate your office from other offices, you install a LAN Router. Most off-the-shelf LAN Routers have only four LAN ports for connecting your computer and other LAN devices together. If you need more LAN devices, you can connect an additional LAN Switch to one of the “Ethernet” ports on the LAN Router and then connect the other LAN devices to the added LAN Switch.

Referred to as an *Isolated System Configuration*, the LAN Router keeps others from interfering with your computer and LXI Device. The LAN Router has a built-in Gateway that allows your computer and other LAN devices to access the company LAN through that Gateway, but other company LAN devices cannot “see” behind the Router without special configuration of that Router. The four ports labeled as “Ethernet” are really a LAN Switch built into the LAN Router. The “Internet” port connects to your company LAN. Refer to the document *LXI Networking Basics* for more information about the capabilities of a LAN Router.

Connect your computer and LXI Device to the LAN Router, according to Figure 3.4. Do NOT connect the LAN Router’s “Internet” connection to the company LAN at this time. *Section 4, Connecting to the Company LAN* will discuss the steps needed to make that transition.

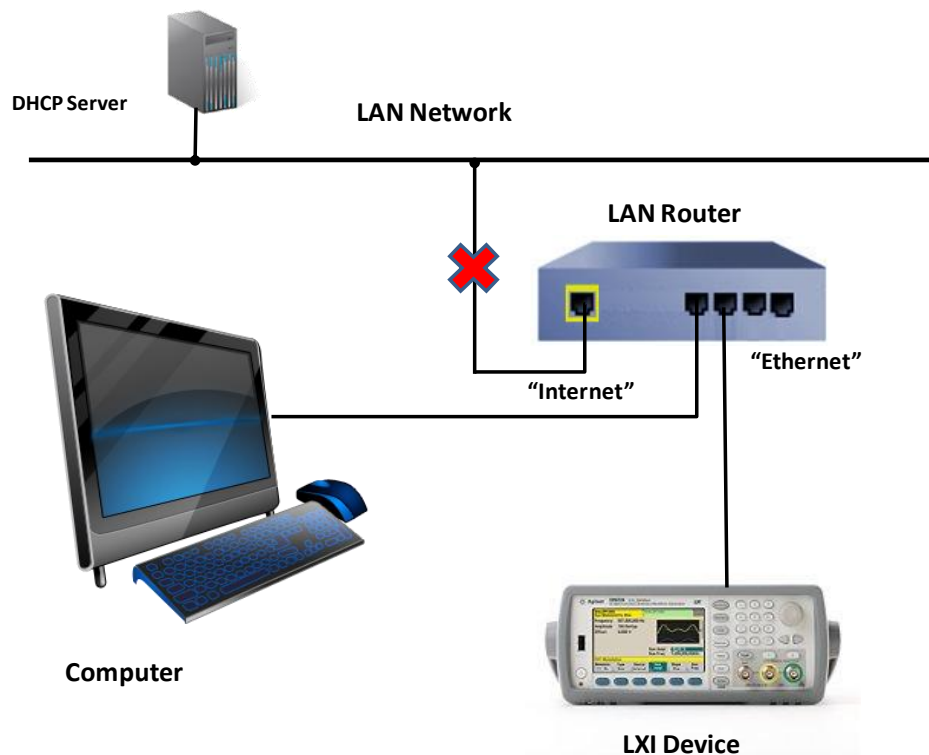


Figure 3.4 *Isolated System Configuration* using a LAN Router

3.2 Discover

Use the *LXI Discovery Tool* installed in *Section 2* to find the LXI Device’s IP address, so you can bring up its Web pages. This tool discovers all LXI Devices, since it understands the services and protocols required by the LXI Specification.

You can also use the *Agilent Connection Expert*, *NI MAX*, or *TekVISA Configuration* to discover LXI Devices. These tools are very advanced and provide discovery of devices connected to other types of computer interfaces. We will focus only on using the *LXI Discovery Tool* in this document.

Run the *LXI_Discovery.exe* program. The left image in Figure 3.5 illustrates the results of the computer and LXI Device connected to a LAN Switch, with the LAN Switch disconnected from the company LAN. The IP address falls into the range of **169.254.x.x**, which is a private IP address assignment used in a process called AutoIP, also referred to as Link-Local addressing. AutoIP takes place when there is no DHCP Server (Dynamic Host Configuration Protocol) to assign IP addresses. In this configuration, the computer and LXI Device pick their own IP address and negotiate with each other to make sure they do not pick the same IP address.

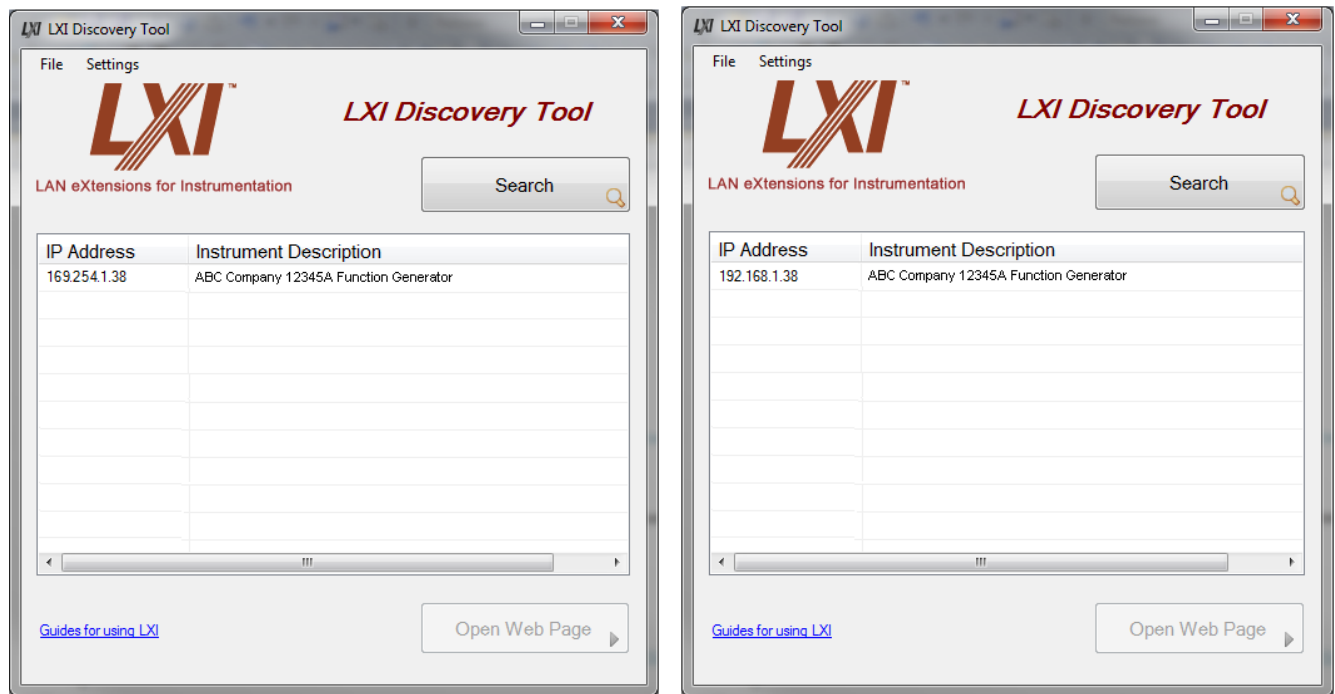


Figure 3.5 LXI Discovery Tool Results LAN Switch and LAN Router

If using the *Isolated System Configuration* of *Section 3*, the right image represents the computer and LXI Device connected to the Router. The LAN Router has a built-in DHCP Server to assign IP addresses to each LAN Device connected to the “Ethernet” ports. Most Routers default to the private IP address range of **192.168.1.x**, but they also permit selection of any IP address range.

Note in Case of Difficulty

If no device shows up when pressing Search on the *LXI Discovery Tool*, please refer to *Appendix A. Troubleshooting*. If a device found is not descriptive of the LXI Device you are using, the next section will describe how to bring up the device’s Web page for true identification.

3.3 View and Identify

The *LXI Discovery Tool* has discovered the LXI Device in the previous step, and now it is time to explore the device's Web pages. Each LXI Device is required to serve up Web pages that show its current configuration and allow modification of that configuration. Each vendor can vary its Web page look and feel, but all LXI Devices are required to show certain configuration information and allow changing the configuration of the LXI Device's LAN operation.

To gain access to the LXI Device's home Web page, click on the discovered device's entry in the *LXI Discovery Tool* results (refer back to Figure 3.5) and press the *Open Web Page* button, or type in the IP address of the LXI Device into a Web Browser's URL (Uniform Resource Locator) line.

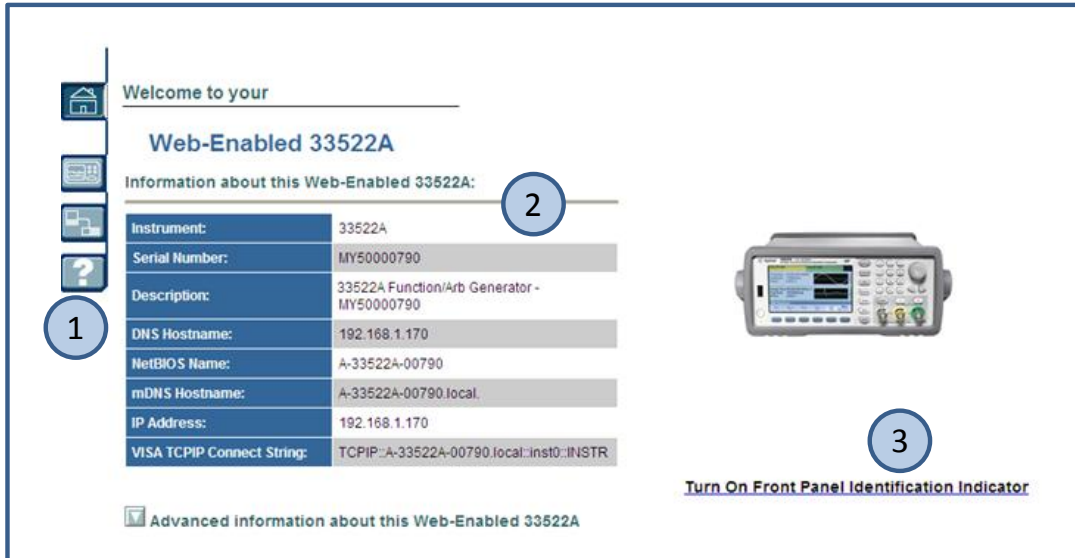


Figure 3.6a Example #1 LXI Device Home Web Page

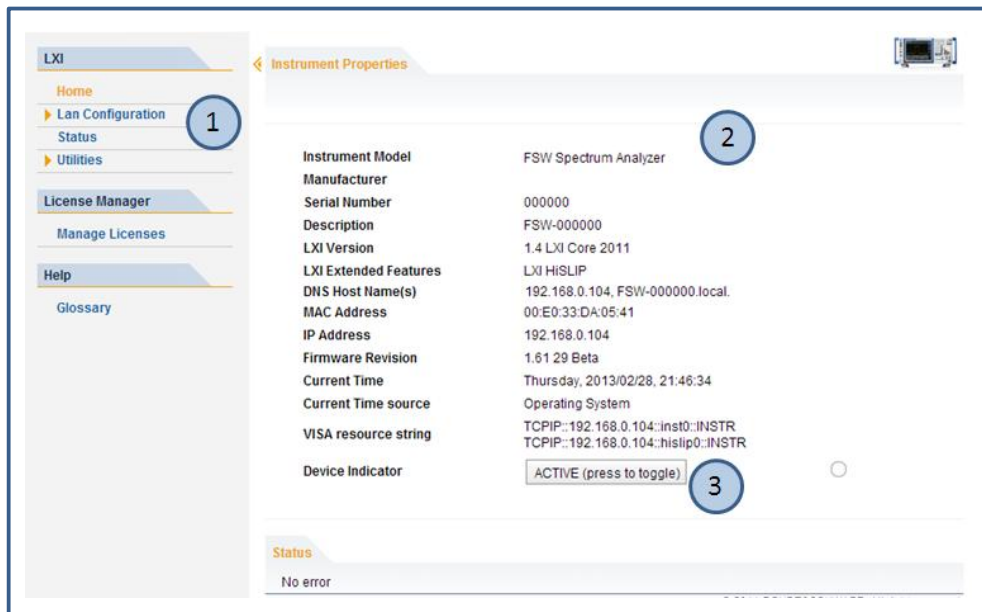


Figure 3.6b Example #2 LXI Device Home Web Page

It varies from vendor to vendor, but the following are three key areas of information, identified by the numbers in Figures 3.6a and 3.6b:

1. **Navigation Buttons** These tabs on the left navigate through the other LXI Device Web pages. The LAN Configuration page is of key importance, for that page allows you to change the way the LXI Device behaves over the LAN. In Figure 3.6a, an icon shows connection of a device to a computer, designating the LAN Configuration. In Figure 3.6b, it has specific labeling. There is also help in the navigation area and access to other Utilities the vendor provides. In many cases, there is a Web Browser Control button to bring up a virtual Front Panel or a Windows-type interface for monitoring or controlling the instrument remotely. Navigating to the Web Browser Control or LAN Configuration is password protected to avoid unauthorized users access to changing instrument settings. *Appendix C Additional Capabilities of LXI Devices* provides examples on Web Browser Control from the Web page.
2. **Device Information** This table illustrates important information about this LXI Device when operating on the LAN – hardware MAC address, IP address, Hostname, VISA Address String, LXI Version, LXI Extended features, etc. **The MAC address plays a critical role in Section 4 when connecting an LXI Device to the LAN.** The MAC address can also be found on the Front Panel display and typically found under a Menu softkey or Front Panel key labeled System or Utility. For LXI Devices that have no display or a very limited display, a label with the MAC address on the rear panel will be present.
3. **Device ID Indicator** When pressed, a Front Panel indicator helps you find this particular LXI Device among others. When ON, the LXI Device’s Front Panel will display some sort of text message, or an LED will blink on the Front Panel to catch your attention. This is especially helpful when building a Test System where there are multiple LXI Devices installed in a test rack. In Figure 3.7, each of the labels has an LED to indicate status information. The LAN indicator will blink ON and OFF to indicate selection.

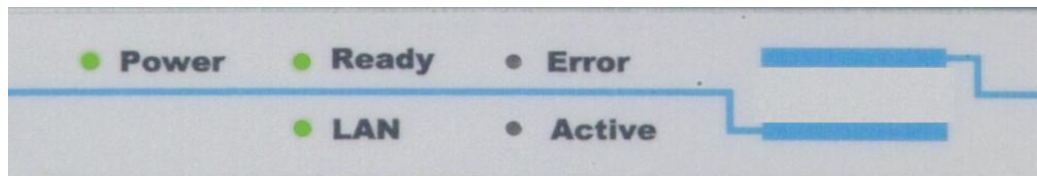


Figure 3.7 LED Indicators on LXI Device without a Front Panel display

LAN Configuration Page Insights

A LAN Configuration page is required to be LXI conformant, but there be multiple ways to present the information. In Figures 3.8, two examples are illustrated. This section will only identify important characteristics required for all LXI Devices. Please refer to the LXI Device’s documentation on LAN Configuration for specific guidance to configure it properly.

Notice in Figure 3.8a, the Automatic (DHCP and AutoIP) vs. Manual settings for IP Address configuration. When set to Automatic, the LXI Device requests an IP address from a DHCP Server when connecting to the company LAN. A Router also provides a built-in DHCP Server. If a DHCP Server does not respond, the LXI Device performs AutoIP and will pick an IP address and broadcast that choice on the LAN. If no other device objects, it keeps and uses the IP address. Manual would permit you to set your own IP address. When connecting, the LXI Device broadcasts that choice, and if any other device already has that IP address, the LXI Device will disconnect from the LAN and remain in the LAN Status Fault mode, with an address of **0.0.0.0** and a LAN Status Indicator on the Front Panel presenting a failed configuration. Refer to the document *LXI Networking Basics* for more information on the behavior of LXI Devices on the LAN.

Parameter	Value
IP Address Configuration:	<input checked="" type="radio"/> Automatic <input type="radio"/> Manual
IP Address:	<input type="text"/>
Subnet Mask:	<input type="text"/>
Default Gateway:	<input type="text"/>
DNS Server Address Configuration:	<input checked="" type="radio"/> Automatic <input type="radio"/> Manual
Preferred DNS Server:	<input type="text"/>
Alternate DNS Server:	<input type="text"/>
Desired Hostname:	A-33522A-00790 (Requires reboot to take effect)
Description:	33522A Function/Arb Generator - MY50000790
mDns Enabled:	<input checked="" type="checkbox"/> Enabled
Password:	<input type="checkbox"/> Set a Password <input type="text"/> (Enter New password) <input type="text"/> (Confirm New password)

Figure 3.8a Example #1 LXI Device Configuration Page

Home	IP Configuration								
IP Configuration	<table border="1"> <tr> <td>Hostname</td> <td><input type="text" value="box"/></td> </tr> <tr> <td>Domain</td> <td><input type="text"/> DHCP server did not assign domain name</td> </tr> <tr> <td>Description</td> <td>LXI 10 AMP 1-POLE MATRIX Simulator</td> </tr> <tr> <td>Service Name</td> <td>60-600-025 - 0001C0068A0E</td> </tr> </table>	Hostname	<input type="text" value="box"/>	Domain	<input type="text"/> DHCP server did not assign domain name	Description	LXI 10 AMP 1-POLE MATRIX Simulator	Service Name	60-600-025 - 0001C0068A0E
Hostname	<input type="text" value="box"/>								
Domain	<input type="text"/> DHCP server did not assign domain name								
Description	LXI 10 AMP 1-POLE MATRIX Simulator								
Service Name	60-600-025 - 0001C0068A0E								
Security	<input type="button" value="Submit"/> <input type="button" value="Reset"/>								
Instrument Control	<table border="1"> <tr> <td>TCP/IP Mode</td> <td> <input checked="" type="checkbox"/> DHCP --> <input checked="" type="checkbox"/> Auto-IP --> <input checked="" type="checkbox"/> Manual </td> </tr> <tr> <td></td> <td>IP configuration sequence, at least one configuration must be selected</td> </tr> </table>	TCP/IP Mode	<input checked="" type="checkbox"/> DHCP --> <input checked="" type="checkbox"/> Auto-IP --> <input checked="" type="checkbox"/> Manual		IP configuration sequence, at least one configuration must be selected				
TCP/IP Mode	<input checked="" type="checkbox"/> DHCP --> <input checked="" type="checkbox"/> Auto-IP --> <input checked="" type="checkbox"/> Manual								
	IP configuration sequence, at least one configuration must be selected								
Diagnostics	<table border="1"> <tr> <td>IP Address</td> <td><input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="110"/></td> </tr> <tr> <td>Subnet Mask</td> <td><input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="0"/></td> </tr> <tr> <td>Default Gateway</td> <td><input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="254"/></td> </tr> <tr> <td>DNS Server(s)</td> <td> <input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="13"/> <input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="7"/> </td> </tr> </table>	IP Address	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="110"/>	Subnet Mask	<input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="0"/>	Default Gateway	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="254"/>	DNS Server(s)	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="13"/> <input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="7"/>
IP Address	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="110"/>								
Subnet Mask	<input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="255"/> . <input type="text" value="0"/>								
Default Gateway	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="254"/>								
DNS Server(s)	<input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="13"/> <input type="text" value="192"/> . <input type="text" value="168"/> . <input type="text" value="1"/> . <input type="text" value="7"/>								
Documents & Drivers	<input type="button" value="Submit"/> <input type="button" value="Reset"/>								
Help									

Figure 3.8b Example #2 of LXI Device Configuration Pages

4 Connecting to the Company LAN

Section 3 brought you through the steps of connecting the LXI Device and computer together. That section disconnected the company LAN to permit a successful discovery of the LXI Device. An important piece of information, the hardware MAC address of the LXI Device, became available during that discovery process that can prove very valuable in this section.

A primary issue is the acquisition of an IP address for the new device when connecting to the company LAN. The *Isolated System Configuration*, using the LAN Router, can complicate the access of the computer to the Internet and other company resources, since the computer must now operate through the LAN Router instead of directly connected to the company LAN. Because companies have varied policies for connecting new devices to the LAN, one needs to consider what those might be before proceeding. The following examples cover almost all the various case you are likely to encounter when connecting to the company LAN:

1. **Allow all LAN Devices** The DHCP Server on the LAN will allow any device to be connected. It hands out IP address irrespective of the type of LAN Device. This is actually quite common, and it is a common setup in Home LANs. Since connecting a wireless Router to this type of network can be a security risk, companies often have wireless signal detection to track down any un-authorized broadcasts and will quickly find the offending device and remove it from the company LAN.
2. **Allow all but Routers** Similar to the first case, the DHCP Server on the LAN will allow any device *except* a LAN Router. When connecting to the company LAN, one of the parameters exchanged with the DHCP Server during the discovery process is the hardware MAC address of the device. The DHCP Server can detect a Router by its hardware MAC address, and it can reject giving it an IP address. This can be a breach in security, since LAN Routers often have built-in wireless capabilities. The Network Administrator wants to control all access to the company LAN, and an open wireless Router could give access to unauthorized Users.
3. **MAC Address Registration** The DHCP Server on the LAN will hand out an IP address, but only when finding the LAN Device's MAC address in its registration table. This means you have to involve your Network Administrator in the process of attaching the LXI Device to your company LAN. If you desire the *Isolated System Configuration* using a LAN Router, you should only have to register the hardware MAC address of the LAN Router. The computer – behind the Router - now accesses the Internet and company resources using the Router's IP Address.
4. **Static IP Addresses** There is no DHCP Server handing out IP addresses. Each device has a static IP Address. This means you have to involve your Network Administrator to find out the IP Address information needed. It also means you have to open the LXI Device's Configuration page to assign it a static IP address instead of using the default Automatic mode of requesting an IP Address from a DHCP Server. If the LXI Device has a Front Panel with keys, that also provides a means for setting the Static IP Address. The document *LXI Networking Basics* provides an example of Front Panel manual changes to the IP Address, Subnet Mask, and other parameters.

For the *Isolated System Configuration* with the LAN Router, you use the assigned IP address for the Router. The Network Administrator can assist configuring the Router with a static IP address. All of the LXI Devices and computer can remain in the Automatic IP address configuration, since they obtain their IP addresses from the Router's built-in DHCP Server.

4.1 Open System Configuration

Since the “**Allow all LAN Devices**” from the previous discussion is a common configuration for companies with multiple Users accessing LAN Devices from office to office, let us assume that case for the *Open System Configuration*. Reconnecting the LAN Switch to the LAN will require the LAN devices obtain new IP addresses from the DHCP Server. Since the computer and LXI Device acquired an AutoIP address in *Section 3*, use the following steps to cause the devices to drop their AutoIP addresses and acquire new DHCP Server addresses when connecting to the LAN:

- Disconnect the computer and LXI Device from the LAN Switch for 30 seconds, a time often required for LAN Devices to detect the LAN cable has been disconnected
- Connect the LAN Switch to the company LAN
- Reconnect the computer and LXI Device to the LAN Switch
- The DHCP Server will hand out new IP addresses to the computer and LXI Device

The *LXI Discovery Tool* can now search for any LXI Device that might be located on the LAN. Figure 4.1 illustrates the connection of your office with the company LAN. It also shows a number of other LXI Devices connected to the company LAN and visible to your computer. Whether connected directly to the LAN or through a LAN Switch does not matter. They are accessible.

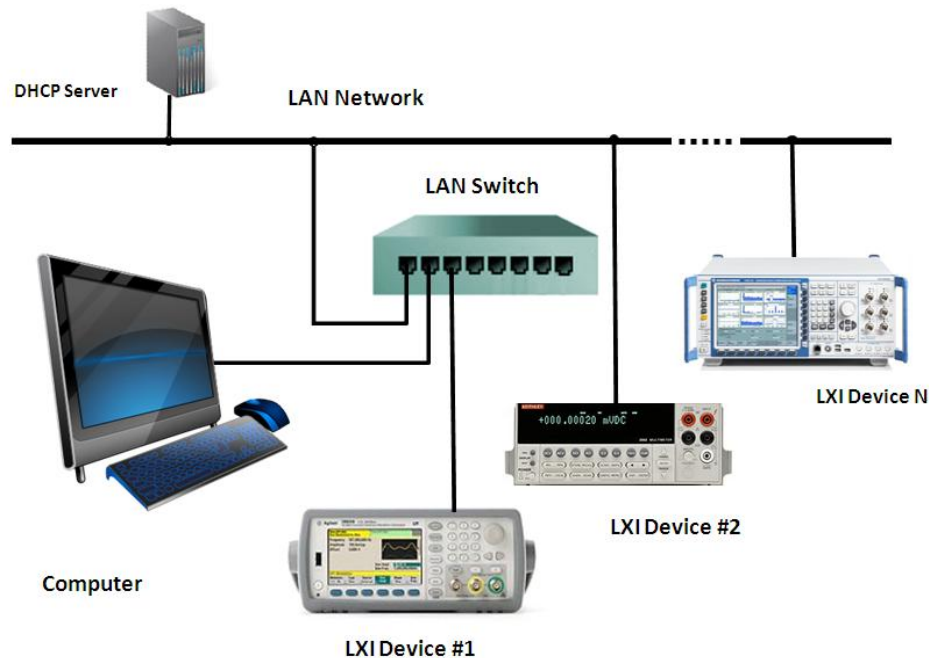


Figure 4.1 Open System Configuration with DHCP Server

Figure 4.2 shows the *LXI Discovery Tool* finding many LXI Devices, which is common in companies who build and test electronic products. For an *Open System Configuration*, Test Systems containing many LXI Devices exist on the LAN and permit access by multiple test engineers for developing test procedures. Notice the entry in Figure 4.2 that does not identify an instrument. This can occur when non-LXI Devices support one of the LXI Device protocols, or it occurs for first-generation LXI Devices (LXI 1.0 and LXI 1.1) using an identification protocol that requires programmatic access to the instrument for identification. Starting with the LXI 1.2 Standard, device identification information became accessible through the Home page of the instrument. To find out if this is an LXI Device, simply click to select the device and press the *Open Web Page* button. You will know what the device is when its Web page appears.

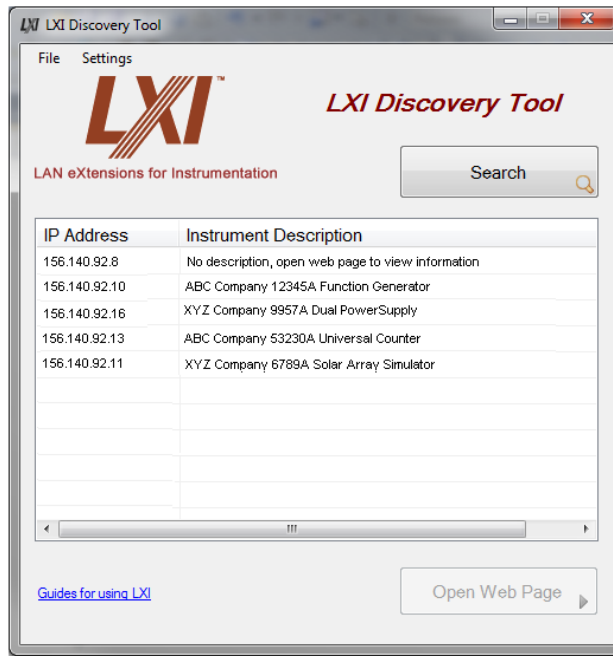


Figure 4.2 LXI Discovery Tool on Open System Configuration

NOTE: If you encounter problems during this discovery process, please refer to **Appendix A. Troubleshooting** for insight into what may be an issue.

4.2 Isolated System Configuration

The *Isolated System Configuration*, assuming “**Allow all LAN Devices**”, would not be different from *Section 3*, since the computer and LXI Device are still the only two devices on that subnet. The *LXI Discovery Tool* will still only find one LXI Device. The LAN Router picks up the IP address from the DHCP Server, and the computer can now access the Internet and company resources through the IP address of the Router. Figure 4.3 illustrates the configuration. If you encounter problems during this discovery process, please refer to **Appendix A. Troubleshooting** for insight into what may be an issue.

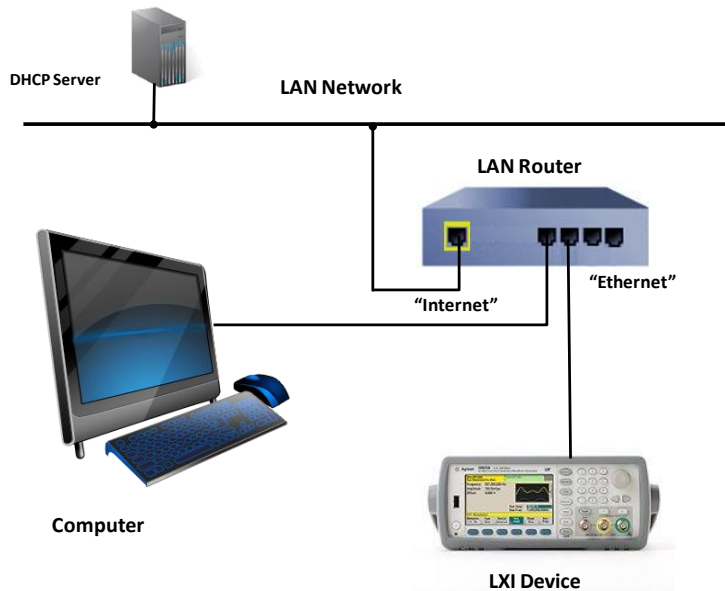


Figure 4.3 Isolated System Configuration

5 Next steps in controlling the LXI Device

LXI Devices are required to provide an IVI Driver (Interchangeable Virtual Instrument). IVI Drivers provide a common look and feel for controlling all LXI Devices, which shields the programmer from a variety of product control differences. IVI Drivers can operate in a number of different development environments. Here are the various development environments currently supported by IVI Drivers:

- Agilent VEE Pro
- MathWorks MATLAB®
- Microsoft® Visual Studio C#, C++, and Visual Basic
- National Instruments LabVIEW® and LabWindows CVI

The LXI Device vendor must register its IVI Driver on the *IVI Foundation* website, located at www.ivifoundation.org. A link to the LXI Device's IVI Driver on the manufacturer's website provides a means to download the IVI Driver. You will also find *IVI Getting Started Guides* for each of the above development environments on the *IVI Foundation* website.

A CD or DVD usually ships with the LXI Device for installing the recommended Interface Library. For many LXI Devices, this is the VISA (Versatile Instrument Software Architecture). For others LXI Devices not using VISA, the installation procedure specifies the Interface Library. Install the Interface Library first and then install the IVI Common Components and LXI Device Driver, as described fully in the particular development environment *IVI Getting Started Guide*

The IVI Driver installation also includes an **Examples** directory with project solutions and source code for the various development environments mentioned earlier. The *IVI Getting Started Guide* describes how to find the root directory of the installed driver, from which you can find **Examples**.

6 Building LXI-based Test Systems

The *LXI Consortium* created the document *Building LXI-based Test Systems* as the next step in your learning process. This is the document needed when building a Test System consisting of multiple LXI Devices. It builds upon this *LXI Getting Started Guide* by expanding the *Open* and *Isolated System Configurations*.

The *Open* and *Isolated System Configurations* each have benefits and cautions discussed in that document. Various Test Systems are illustrated with these benefits and cautions summarized to assist in picking the Test System configuration that works for your company.

Performance, accessibility, security, and flexibility are among the factors involved in building a successful Test System. LAN Device hardware recommendations include the use of the LAN Switch, LAN Router, and multiple network interfaces. Programming practices using IVI Drivers and the flexibility of the VISA Address Strings makes it easier to convert your existing software to controlling LXI Devices, which may have been using USB or GPIB (General Purpose Interface Bus).

Building LXI-based Test Systems will also reinforce the need to get your Network Administrator involved in the choice of LAN equipment and the configuration of that equipment into building a Test System that operates reliably and properly on your company's LAN.

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MATLAB® is a trademark or registered trademark of MathWorks Corporation

LabVIEW® is a trademark or registered trademark of National Instruments Corporation

7 Introducing LXI to your Network Administrator

Section 4 described that adding an LXI Device to your LAN may require assistance from your Network Administrator. The LXI Consortium created *Introducing LXI to your Network Administrator* specifically to help them understand how LXI Devices behave on the LAN. The Network Administrator needs to know what protocols, services, ports, security, and performance your LXI Device requires. They need to know how many IP addresses your Test System will need. They need to be aware that a Test System must run at maximum performance and without intervention of LAN maintenance processes when running test programs.

This document gives the busy Network Administrator information in summary form with just enough facts presented for quick analysis. The Network Administrator will see the recommended Test System Configurations and the recommended LAN hardware. They will be involved in the selection and configuration of that LAN hardware in order to maintain the integrity of the LAN. This is the document you can hand your Network Administrator that will ensure that both their needs and your Test System needs meet the company requirements for LAN integrity and successful testing.

Appendix A. Troubleshooting

This appendix mostly provides insight into problems during the *Discovery* process discussed in *Section 3*. It also reaffirms the need to talk to your Network Administrator if you cannot acquire an IP Address when connecting to the company LAN (*Section 4*). The problems found assume a connection oriented problem and not due to failures of the LXI Device's hardware, although diagnosing hardware failures follow these same suggestions. Figure 3.3 and Figure 3.4 provide the basic configurations for this troubleshooting section. The following are the key problems covered in this appendix:

- LAN Status Fault shown on LXI Device
- Cannot Discover LXI Device with *LXI Discovery Tool*
- No IP Address when reconnecting to the company LAN
- LXI Discovery Tool finds the LXI Device, but I can't access the Web page

The *LAN Status Fault shown on LXI Device* condition may be common to other problems, so references back to this condition will occur often.

LAN Status Fault shown on LXI Device

Figure A.1 illustrates several examples from various LXI Devices where a LAN Status Fault condition has occurred. The top line in Figure A.1 is an excerpt from the Front Panel display of an instrument and typically found under the Utility or System keys. Notice the combination of an IP Address of **0.0.0.0** and the Red LAN Status Fault. The lower example is a monochrome display, so its LAN Status Fault is an asterisk. The example in the middle has no display, so it sets its LAN Status indicator to Red.

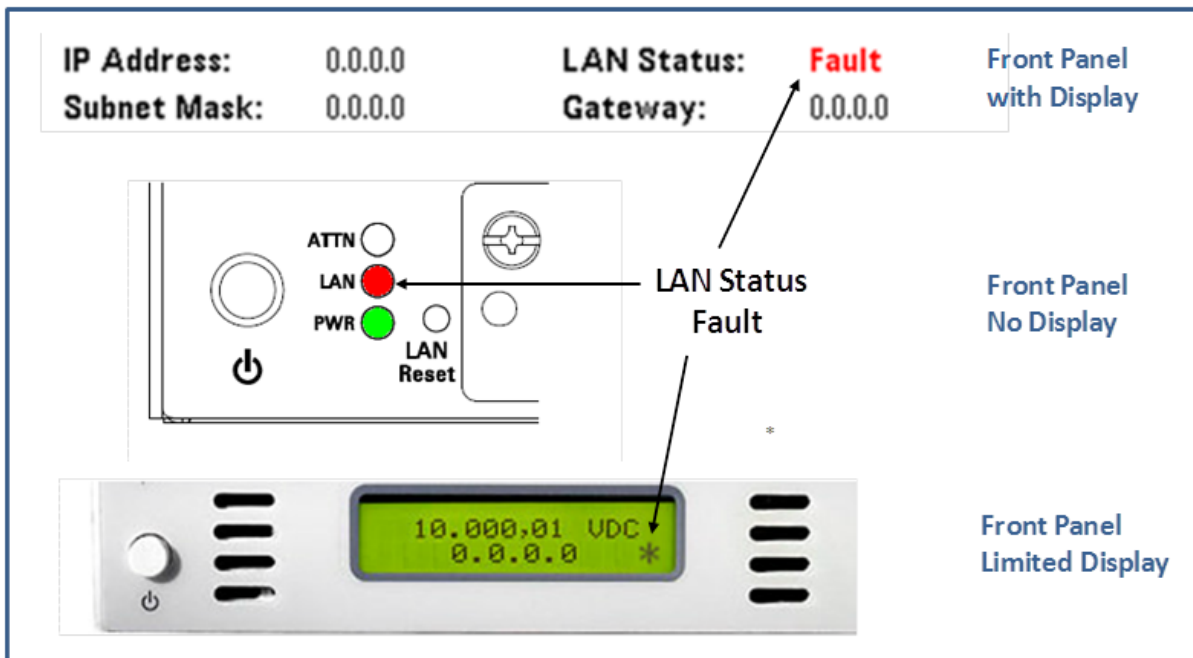


Figure A.1. LAN Status Fault Examples

The following are likely causes of the LAN Status Fault:

- The LAN Cable is bad or disconnected from the LXI Device.
 - Verify the LAN cable completely inserts into the RJ45 Connectors of the LAN Switch and LXI Device. Make sure it clicks when inserted indicating it has locked into place.
 - Verify the LAN cable is not defective by trying a different cable or using the suspected cable in a known good configuration.
- The Switch or Router is OFF.
- The LXI Device tried to use an IP Address of another LXI Device on the subnet. This is a duplicate IP Address error, so the LXI Device disconnects itself from the LAN.
- The DHCP Server issues an IP Address for a limited time – called the Lease Time. If the DHCP Server is no longer available to renew the lease, the LXI Device will move to the AutoIP mode (**169.254.x.x** address) and assert the LAN Fault indicator showing it has changed IP Addresses. This is not likely to happen and especially not after power-ON, because lease times are typically 24 hours.

Check the first two conditions and cycle power on the LXI Device. If the problem persists, it is likely the LXI Device has a Static IP Address already in use by another LAN Device connected to the Switch or Router and created a Duplicate IP Address error condition. The LCI (LAN Configuration Initialize) or LAN Reset mechanism resolves this type of problem.

An LCI resets the LXI Device to DHCP Addressing Mode, resets Web page password to its default documented setting, and re-enables the mDNS (Multicast Domain Name Service) discovery mechanism. LXI Devices with LXI 1.3 Standard and above have the mDNS discovery mechanism.

The LCI mechanism is a recessed button on the LXI Device or as a softkey in a menu, usually under the Utility or System keys. Figure A.2 illustrates an instrument with the LCI mechanism on both the front and rear of the LXI Device. LCI and LAN Reset are common labels on LXI Devices and refer to the same operation. Reaching the LCI button may require using a paper clip. The LXI Device will then restart its LAN and attempt to acquire an automatic IP address. Allow 30 seconds for the restart process and then run the *LXI Discovery Tool* again.

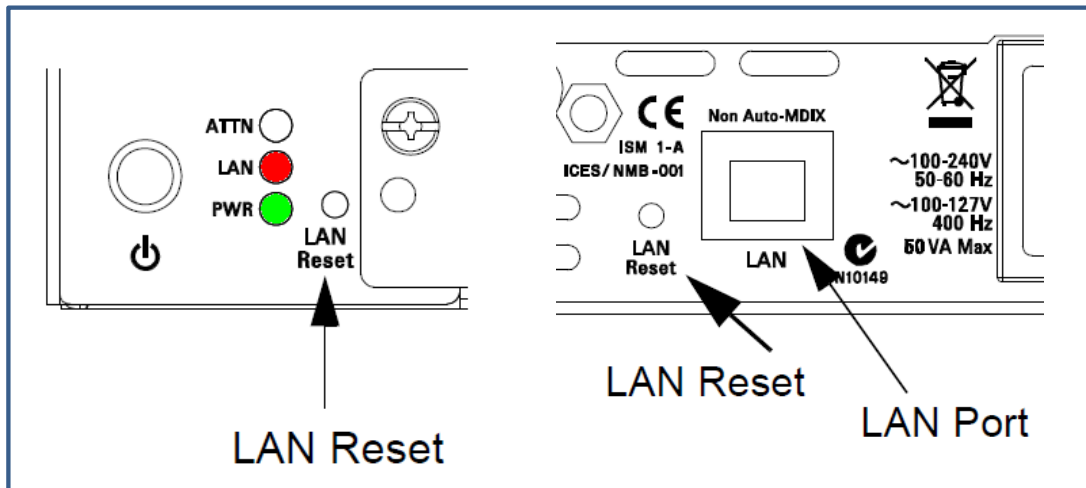


Figure A.2. LCI or LAN Reset mechanism

Cannot Discover LXI Device with *LXI Discovery Tool*

You have performed the Search with the LXI Discovery Tool but no LXI Device found. If there is an entry in the table that says “No description, open web page to view information”, then select the entry and press the *Open Web Page* button.

If the table is empty after searching, then there is a problem in discovering the LXI Device’s IP Address. Check the LXI Device’s LAN Status to see if it has a LAN Status Fault condition. If so, follow the directions given in the first problem case, *LAN Status Fault shown on LXI Device*.

If there is no LAN Status Fault indication on the LXI Device, then it is possible the LXI Device has a Static IP Address that is valid but not reachable by the computer – not in the same subnet. Perform the LCI or LAN Reset as described in the previous problem case, *LAN Status Fault shown on LXI Device*. Since there is no Duplicate IP Address and thus a no LAN Status Fault, performing the LCI will reconfigure the LXI Device into the same subnet as the computer.

One other possibility is the computer’s IP Address. If the computer has a static IP Address not mapping to the same subnet as the LXI Device, then configure the computer to either use DHCP, or a static IP Address and subnet mask matching the subnet of the LXI Device. Configuring your computer’s IP Address is beyond the scope of this document and varies widely between operating systems. Please ask your Network Administrator for help in this situation.

No IP Address when connecting to the company LAN

If the LXI Device is not found or its IP Address falls into the **169.254.x.x** range when connecting to the company LAN, then it is likely due to the DHCP Server not allowing new LAN devices without first registering them with the DHCP Server. The problem could also be the need for a Static IP Address assignment to the LAN Device. In both of these cases, you need to talk to your Network Administrator to resolve the situation. Come prepared with the MAC address of the LXI Device, so he can add it to the DHCP Server’s configuration table. Follow the MAC address discovery process described in *Section 3*.

LXI Discovery Tool finds the LXI Device, but you can’t access the Web page

This is likely to happen only with LXI Devices with mDNS discovery. The LXI Standard requires mDNS discovery since version 1.3. However, some LXI Devices incorporated this mechanism prior the requirement in the LXI Standard. In this situation, the mDNS discovery mechanism has discovered the LXI Device, but its IP Address does not match the subnet of the computer.

To resolve this condition, activate the LCI mechanism, as described in the problem scenario *LAN Status Fault shown on LXI Device*. This should force the LXI Device’s IP Address into the same subnet as the computer.

If this does not clear up the problem, then the computer has a static IP Address not mapping to the same subnet as the LXI Device. Configure the computer to either use DHCP, or a static IP Address and subnet mask matching the subnet of the LXI Device. Configuring your computer’s IP Address is beyond the scope of this document and varies widely between operating systems. Please ask your Network Administrator for help in this situation.

Appendix B. What LXI Conformance Means

A majority of the major measurement instrument manufacturers established the first version of the LXI Standard in 2005 to bring about a common behavior for LAN equipped instruments. It was a huge step in compatibility such that a test engineer that builds a test system with LXI conformant devices can rely upon that LXI common behavior and programming tools.

The LXI specification consists of established LAN standards assembled together with many additional rules and recommendations to ensure compatibility. LXI conformance means the particular device adheres to the LXI specification and has passed some tough third party testing before claiming conformance.

All LXI conformant devices will connect to the LAN in a known and predictable manner, and they all have Web pages for describing their LAN communication and configuration. In addition, all LXI conformant devices must supply an IVI Driver (Interchangeable Virtual Instrument), which provides a common programming interface. Such compatibility never existed with LAN-based instruments prior to the LXI standard.

Prior to the LXI Standard, it was very difficult to mix LAN equipped instruments together into a Test System, especially from different vendors of equipment. In some cases, it was also difficult to integrate LAN equipped instruments from the same vendor. Unless that vendor had internal standards to follow between its Project Teams, this could easily happen.

If you see the LXI Logo on an instrument or on its Front Panel display, it will behave in a predictable manner when connected to the LAN. It will also include an IVI Driver with a common interface for programming that makes it much easier to develop test programs.

Appendix C. Additional Capabilities of LXI Devices

There were certain features of LXI Devices mentioned earlier in this document.

- Different types of LXI Devices
- Connecting a LAN cable between your Computer and the LXI Device
- LXI Devices with Web Browser Control
- Extended Functions of LXI Devices

Different types of LXI Devices

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	Solar Array Simulators
Network Analyzers	Switches

The devices just mentioned are typically single instrument standalone products, but there are also LXI Card-cage devices built with plugins that are virtually an instrument-on-a-module. In this case, a single IP Address accesses multiple devices within a single card-cage or possibly multiple card-cages daisy chained together. It does not matter if the underlying technology of accessing these modules is PCI, (Peripheral Control Interface), PXI (PCI eXtensions for Instrumentation), VMEbus (Versa Module European), VXI (VMEbus eXtention for Instrumentation), proprietary interface, etc. The Card-cage LXI Device abides by all the same requirements as a single instrument LXI Device. Figure C.1 shows some examples from various vendors. In the Figure, PXI, VXI, and proprietary backplanes are in use.



Figure C.1. Various Card-cage LXI Devices

Connecting a LAN Cable between your Computer and LXI Device

If you are familiar with connecting a USB Cable between your computer and an instrument, you may find it convenient to do the same using a LAN Cable between your Computer and LXI Device. With this configuration, it is not necessary to install any device driver in order to bring up the LXI Device's Web page. Since many LXI Devices include full control of the instrument from the Web pages (Web Browser Control), you can take advantage of those tools to learn the basic operation of the instrument. The next topic covers some examples of Web Browser Control.

Many LXI Devices also operate using an ASCII programming language, such as SCPI (Standard Commands for Programmable Instruments). Those same instruments usually include an Interactive I/O interface from a Web page that allows you to experiment between using Front Panel buttons, the Web page instrument control, and the Interactive I/O, speeding your learning of the LXI Device programming language.

Using a single cable is actually a common configuration with today's laptop computers, since the laptop includes both integrated LAN Wi-Fi and an Ethernet port. Wi-Fi gives you access to email, Internet, etc, and the unused RJ45 LAN connector is free to connect directly to the LXI Device. With this configuration, it is not necessary to use the RJ45 port to connect to the LAN in your office. Figure C.2 illustrates the configuration.

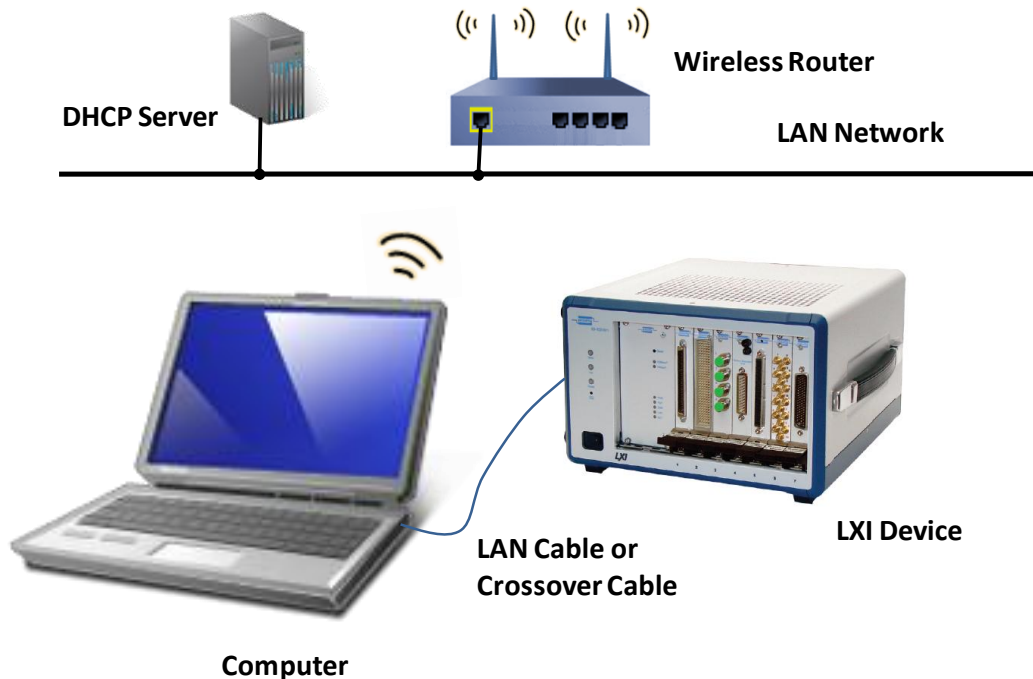


Figure C.2. Computer to LXI Device

If the LXI Device or the Computer come equipped with Auto-MDIX (see Glossary), then it does not matter if you have a regular LAN Cable or a LAN Crossover cable. Auto-MDIX automatically detects the TX (transmit) and RX (receive) lines and switches the signal paths. Most modern computers and laptops come equipped with integrated Gigabit Ethernet, which includes Auto-MDIX. If the LXI Device does not support Auto-MDIX, it must have a label stating so near its RJ45 connector. If neither have Auto-MDIX, the LAN Crossover Cable is required, which swaps the TX and RX lines at one end of the cable. Without this compensation, the computer would not be able to communicate with the LXI Device. The *LXI Discovery Tool* will discover the LXI Device as it did in *Section 3*.

LXI Devices with Web Browser Control

One of the most attractive attributes of an LXI Device is its ability for remote access from 100's of feet to miles away. LXI Vendors have multiple applications of remote control and monitoring. With LAN Technology, the flexibility for remote access attributes to the LAN equipment and software installed between you and the LXI Device. Since LXI Devices have Web page access, an LXI Device with an accessible IP Address is all you need to view or control the device from virtually anywhere.

Many LXI Devices include Web Browser Control for monitoring and controlling. The control ranges from virtual front panels to visual representation of switches and windows-like configurations. It is a powerful feature that can allow users insight into what the LXI Device is doing without having to be physically in front of the device. Some application stories include engineers on one continent analyzing what an LXI Device is doing thousands of miles away on another continent. This is all very possible when the LXI Device and the User are behind the same company Firewall. This configuration described further in the LXI Consortium document, *Building LXI-based Test Systems*.

These LXI Devices can control access with password protection, so that only monitoring is possible, or password protection can exclude all viewing of instrument operation. Figures C.3 represents just a few examples.

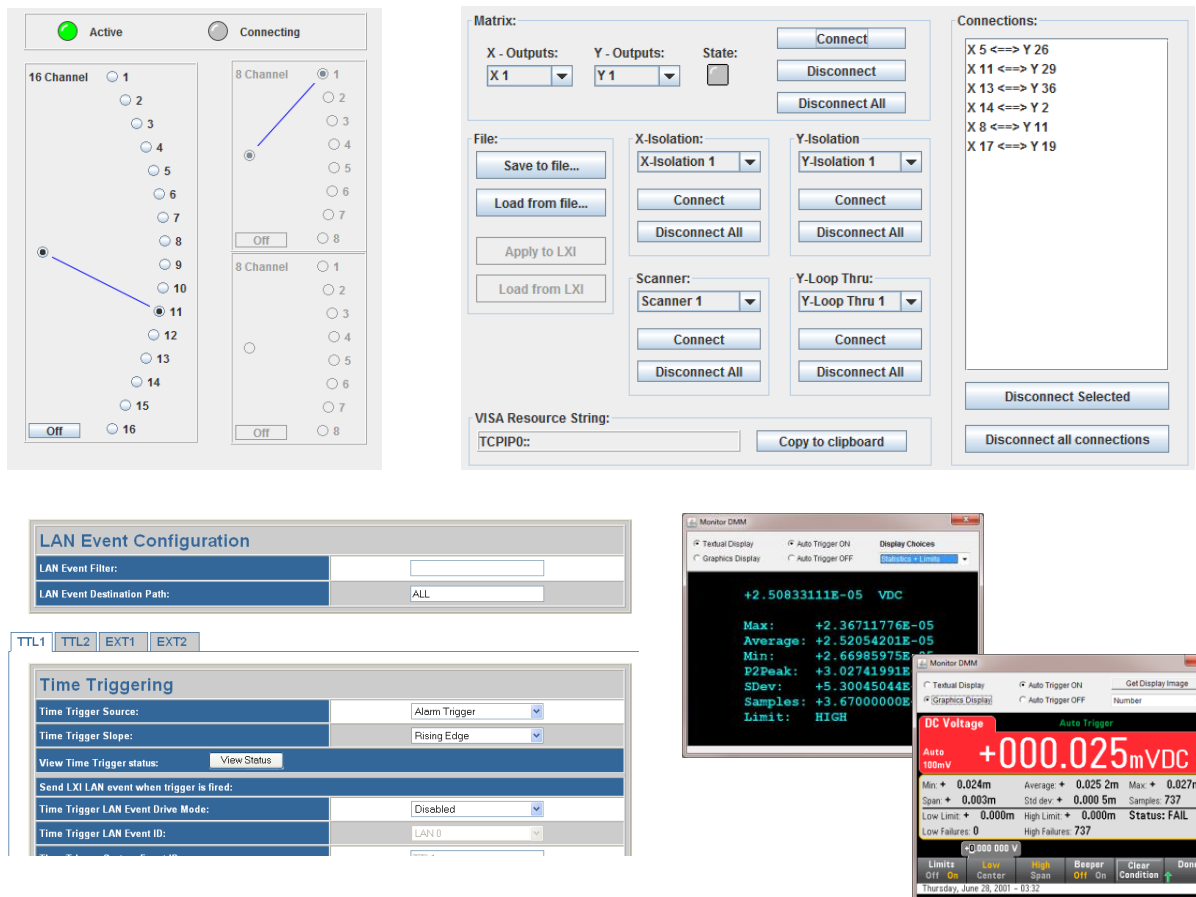


Figure C.3. Various Web Browser Control Examples

Extended Functions of LXI Devices

LXI Device Specification 2011 Version 1.4 defines a set of “Core” features and optional Extended Functions, which have replaced the previous LXI Class A, B, and C. Class A encompassed Extended Functions #1 through #5, listed below. Class B encompassed Extended Functions #2 through #5. Most LXI Devices provide only the “Core” features, which was essentially LXI Class C of previous versions. Extended Functions #6 and #7 added since the release of LXI Device Specification 2011 Version 1.4.

Each Extended Function has conformance requirements in addition to the base, or “Core” class. An LXI device can include one or more of these Extended Functions. More details found in the *LXI Primer* document found at [GuidesForUsingLXI](#).

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 that requiring nanosecond timing.

2. LXI Event Messaging

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

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 tied to absolute times for very precise triggering and synchronization and 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.

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 happened in your instrument or system.

6. LXI 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, and emulate the capabilities of GPIB devices. HiSLIP also operates over IPv6 networks.

7. LXI IPv6

The world must migrate to adopt IPv6, since IPv4 address space on the Internet depleted. The IPv6 Extended Function, adopted by the LXI Consortium, ensures LXI vendors approach IPv6 in a consistent way before its widespread use in test systems occurs.