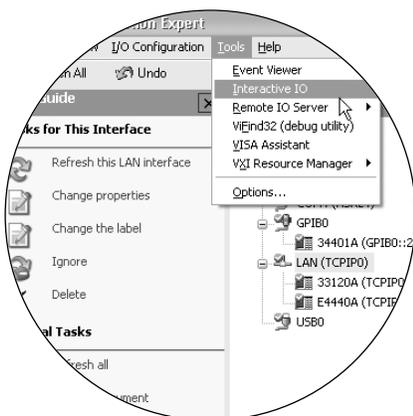
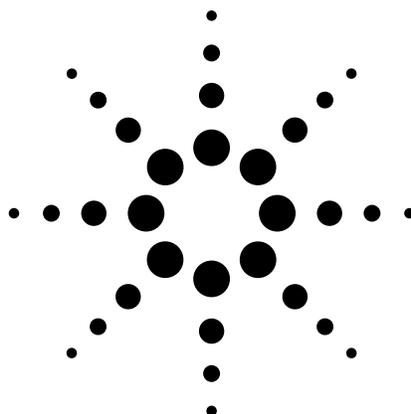


System Developer Guide

Using LAN in Test Systems: Setting Up System I/O

Application Note 1465-15



This set of application notes shows you how to simplify test system integration by utilizing open connectivity standards such as local area networking (LAN). The collective goal of these notes is to help you produce reliable results, meet your throughput requirements and stay within your budget.

Using LAN in Test Systems: Setting Up System I/O, the seventh note in the series, describes the components of the Agilent IO Libraries Suite and presents a quick, six-step process that will make LAN-based instrument connections as simple as using GPIB. This note is a companion to Application Notes 1465-9 through 1465-11, which address the benefits of using a LAN interface in a test system, describe secure topologies for LAN-based test systems, and explain how to enable communication between a PC and LAN-based instrumentation.

Please see page 11 for a list of the other titles in this series.

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Agilent Technologies

Simplifying LAN-based instrument connections

The advantages of LAN technology are making it an attractive alternative to GPIB for system input/output (I/O). As a result, LAN interfaces are becoming more common in test equipment – though LAN ports will likely coexist with GPIB for years to come.

On the surface, the presence of LAN ports in most current-generation PCs and many new-generation test instruments may make connections seem as simple as finding a network cable and plugging it into both devices. Today, making the connection work depends on the LAN services of Microsoft® Windows® and the additional capabilities provided by the Agilent IO Libraries Suite¹. A quick, one-time configuration process will make LAN-based instrument connections as easy as using GPIB.

Once the IO Libraries Suite is installed and configured, it accelerates the connection process with software libraries and utilities that let you quickly connect instruments to a PC, configure and verify the connections, and get on with your job – whether it entails the creation of instrument-control software or the use of pre-existing application software.

Recapping Application Notes 1465-9–1465-11

Several factors can increase the burden on the I/O connection in a test system. Examples include the number of instruments in the system and the volume of commands, status messages and test data being transferred. LAN technology is one of the best ways to handle that burden. It offers a fast, low-cost alternative to GPIB, and it surpasses USB with longer reach and locking connectors.

Most current-generation PCs have built-in LAN ports, which means the computing portion of a test system needs minimal physical configuration. LAN ports are also becoming more common in test equipment. Additionally, devices such as the Agilent E5810A LAN/GPIB gateway make it easy to include older, GPIB-only instruments in LAN-based test systems.

The decision to use LAN for system I/O makes it much easier for colleagues to share data, results, reports and so on. However, it also opens the door to malicious threats and inadvertent risks that can affect system performance and integrity. Fortunately, the creation of a private, protected LAN can shield the test system from many of those risks, and ensure maximum throughput. The standard capabilities of most Windows PCs and many low-cost networking devices enable two viable approaches: one is built around a LAN router and the other is based on a PC equipped with two LAN cards.

Creating the right environment within a PC for transparent communication with LAN-enabled instruments depends on the LAN services of Microsoft Windows and several additional capabilities provided by the Agilent IO Libraries Suite. The utilities included with the IO Libraries Suite simplify and accelerate instrument connections and the troubleshooting of connection problems.

¹ We use “IO” rather than “I/O” in the product name because most operating systems don’t allow the slash character in file names.

Meet the Agilent IO Libraries Suite

Agilent IO Libraries Suite 14 is a collection of libraries and utilities that make LAN, USB and GPIB connections equally easy to use within your test system. The *libraries* provide the ability to access instruments from software programs that perform test and measurement (T&M) operations. The *utilities* enable quick, easy connections of instruments to a PC by helping you debug test programs and diagnose problems in a test system.

The IO Libraries Suite is included with more than 100 Agilent instruments as well as the Agilent VEE and Agilent T&M Toolkit software products. The IO Libraries Suite also works with instruments and software from other vendors.

As an introduction to the IO Libraries Suite, let's take a closer look at its three major components: Agilent IO Libraries, Agilent Connection Expert and the I/O utilities.

Agilent IO Libraries

The suite includes three separate I/O libraries. Each provides similar functionality that lets you programmatically control instruments, send commands to them, and receive responses and data.

Agilent VISA

Agilent's implementation of the Virtual Instrument Software Architecture (VISA) is an industry-standard I/O application programming interface (API). You can use it to develop I/O applications and instrument drivers that will be interoperable with applications from many vendors. These applications and drivers will also comply with IVI Foundation standards for instrument communication and control. The current version of Agilent VISA is backwards compatible with previous versions.

Agilent provides both the C API version of VISA and VISA COM.

Agilent VISA COM

This is a Microsoft Component Object Model (COM) implementation of the VISA standard; it is based on the Agilent VISA architecture. Agilent VISA COM also conforms to IVI Foundation standards.

Agilent SICL

Many test systems still rely on the Standard Instrument Control Library (SICL), which Hewlett-Packard (now Agilent) developed to make software as I/O-independent as possible. This modular library for instrument communication works with a variety of computer architectures, I/O interfaces and operating systems. We include it in the IO Libraries to enable compatibility with previous versions of SICL.

In most cases, we now recommend VISA over SICL. The exceptions are applications that require capabilities such as parallel polling that are unique to SICL.

Suggested approach: If you are developing new test and measurement applications, we generally recommend VISA and VISA COM as the most effective solutions for instrument I/O. The best choice of I/O library depends on your preferred programming language, as summarized in Table 1.

Table 1. Programming languages and recommended I/O libraries

Programming language	Recommended I/O library	Supported alternatives	
		Preferred	Historical
Visual Basic .NET, C# and other .NET languages	T&M Toolkit DirectIO ²	VISA COM VISA	—
Visual C/C++	VISA	VISA COM	SICL
Visual Basic 6	VISA COM	VISA	SICL

² Agilent T&M Toolkit 2.0 is a set of measurement and test tools and components for the Microsoft Visual Studio .NET development environment. The T&M Toolkit DirectIO class enables instrument connections from within Visual Studio.

Agilent Connection Expert

The Agilent Connection Expert (Figure 1) is a software utility that helps you connect instruments to a PC – via GPIB, LAN, USB, RS-232 or the VXI interface – in just a few minutes.

You can use Connection Expert to speed and simplify several essential configuration tasks: configure instrument I/O interfaces; connect to instruments over the LAN; automatically discover instruments connected directly to the PC; and browse the test system's structure and connections (PC, interfaces, instruments). Connection Expert also helps you detect and troubleshoot connectivity problems – during the configuration process or later when the system is in use.

To enhance program portability and readability, Connection Expert also lets you create programming aliases for each instrument in the system. The ability to update an alias with a new IP address or hostname can make it easier to handle system migration and changing network settings.

Connection Expert also improves user productivity by including an on-screen task guide that provides shortcuts to common tasks and frequently needed information.

I/O Utilities

A set of six software utilities enhances your ability to quickly configure and debug instrument-to-PC connections.

- **Interactive IO:** Lets you query instruments one command at a time and view the response to each command. This utility can help you learn an instrument's command set or prototype commands and check the instrument's responses before you write any code.

- **Remote IO Server:** Enables connections to instruments that are physically connected to another PC on the network. When the Remote IO Server is running on one PC (the server) you can use instruments connected to that server from separate client PCs by using Connection Expert to configure remote interfaces on the clients.
- **ViFind32 Debug Utility:** When called from a script, viFind32 uses VISA functions to find available resources and then list them in a console window. This utility is useful for verifying that Connection Expert has configured all expected interfaces, and that the expected devices are all attached.
- **VISA Assistant:** Included with older versions of the IO Libraries and provided in the latest version as a convenience. Most of its capabilities are replaced by either Connection Expert or Interactive IO.
- **VXI Resource Manager:** Used to configure the Agilent E8491 IEEE-1394 PC link to VXI interface in systems that include modular VXI hardware.
- **IO Control:** Provides easy access to all of the IO Libraries Suite utilities and the associated documentation. The IO Control icon appears in the Windows notification area (Figure 2), enabling a quick launch whenever you want to use the utilities.

Figure 1. Agilent Connection Expert's easy to follow tree view helps you see connected devices instantly

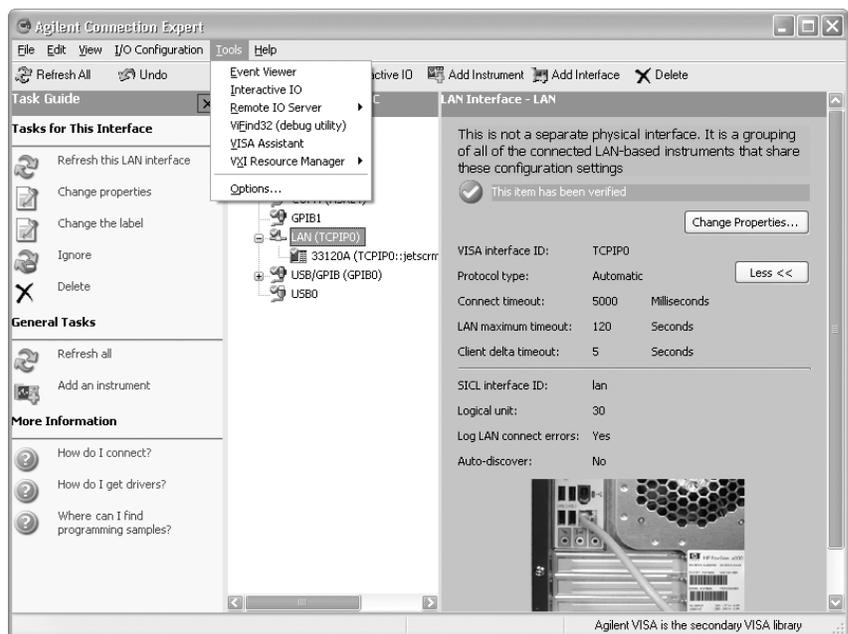
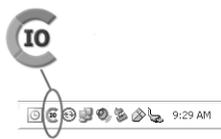


Figure 2. The IO Control icon resides in the Windows notification area



Connecting instruments to LAN

We suggest a six-step process that will help you quickly connect and configure your LAN-enabled instruments. The specific tasks in Steps 2 through 4 depend on whether the instruments are connected to a site LAN or a local, private LAN (these are defined in Step 2). The procedures presented here focus on the private LAN case, which is our recommended approach. If your situation dictates the site LAN approach, please see Chapter 2 of the Agilent Connectivity Guide, which is included with the IO Libraries Suite and is also available at www.agilent.com/find/iolib.

Step 1: Install I/O software

The first step is to install the Agilent IO Libraries Suite on a PC that (a) meets the minimum system requirements and (b) is running a supported version of Microsoft Windows: 98 Second Edition; 2000 with SP4 or later; Millennium Edition (Me); or XP with SP1 or later. For the latest information about PC requirements, please visit the IO Libraries Web page at www.agilent.com/find/iosuite and download the latest version of the product data sheet.

If you don't have the software, you can get a copy from www.agilent.com/find/iosuite by downloading it or requesting a CD (see Web site for licensing restrictions). Once you have a copy of the software on or in your PC, the InstallShield Wizard will guide you through the installation process. (For a detailed description of the software installation process, please see Chapter 6 of the *Agilent Connectivity Guide*.)

Step 2: Select network type

Once you've installed the I/O software, the next step is to decide if you will connect the system instruments and PC to a site LAN or a private LAN.

In this note we define a site LAN to be an enterprise LAN, a corporate intranet or a workgroup LAN. This type of LAN may carry a tremendous amount of data traffic – and network congestion can severely hinder test system performance. A site LAN may also be more susceptible to viruses, Trojans, worms and other threats that pose a security risk to sensitive data. Physically, this type of connection may involve the direct connection of the PC and instruments to the site LAN or a switched connection through a hub, router or switch.

A private LAN is a standalone network reserved exclusively for use by the test system. It is protected from site LAN traffic (and security risks) by either a router (Figure 3) or a PC configured with two LAN cards (Figure 4). The latter configuration will also include at least one hub, switch or router if the system uses multiple instruments. A private LAN implemented with either configuration is our recommended approach. For a detailed description, please see Application Note 1465-10, *Using LAN in Test Systems: Network Configuration*.

A single instrument can also be connected directly to the PC with a crossover Ethernet cable. These cables are usually bright yellow to distinguish them from regular Ethernet cables. This method requires a second LAN card in the PC if the primary LAN card is already connected to the enterprise LAN.

Figure 3. A test system that uses a router-based private LAN

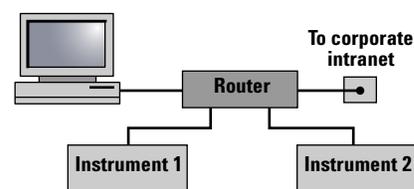
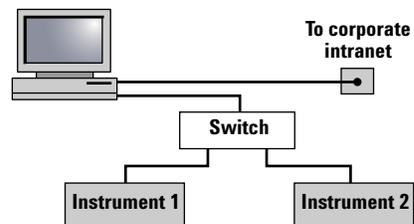


Figure 4. The PC-based solution, with two LAN cards in the PC and a switch to connect the instruments



Step 3: Gather network information

With a private LAN configuration you, as the network designer, are effectively the system administrator and can define network parameters that best suit your test system.

One of the key details is support for dynamic host configuration protocol (DHCP), which automatically assigns IP addresses to devices on the network.³ In general, a router-based private LAN will support DHCP but not Dynamic Domain Name Server (Dynamic DNS), a service that maps specific names to IP addresses and enables use of names in place of IP addresses in test-system programs.⁴

The key information to be gathered or defined is summarized in Table 2: Private LAN information card. You'll want to make a copy of the card for each instrument that will be connected to the test system's private LAN.

Step 4: Connect your instruments

This step assumes that the PC's hardware and software are properly configured for LAN operation and the PC is connected to the private LAN.

As mentioned above, this configuration uses either a router or a PC configured with two LAN cards and a LAN device such as a hub, switch or router. Before connecting any instruments, turn off the power to all instruments. Next, connect each instrument to the LAN device with a standard CAT5 Ethernet cable then turn on power to each instrument. Verify the completion of the power-on sequence for each instrument and, if anything seems unusual, refer to the instrument's *User's Guide* for detailed information.

Hostname versus IP address

We recommend that you configure LAN instruments with a hostname and use it to connect to them whenever possible. IP addresses assigned by DHCP can change without warning, breaking established connections to your instruments. If your network doesn't support connecting by hostname, we recommend the use of a statically configured IP address for each instrument. If any of your instruments are connected to the site LAN, you will need to ask your network administrator to provide static IP addresses for those instruments.

Table 2. Private LAN information card

Network	DHCP enabled	Yes ___ No ___
	Dynamic DNS enabled	Yes ___ No ___
	UPnP enabled OK	Yes ___ No ___
	Subnet mask	____.____.____.____
	DNS server IP address	____.____.____.____
PC	Ethernet (MAC) hardware address	____ ____ ____ ____ ____ ____
	IP address	____.____.____.____
	Subnet mask	____.____.____.____
	DNS server	____.____.____.____
	Hostname	_____
	Domain name	_____
Instrument	Instrument serial number	_____
	Ethernet (MAC) hardware address	____ ____ ____ ____ ____ ____
	IP address	____.____.____.____
	Subnet mask	____.____.____.____
	DNS server	____.____.____.____
	Hostname	_____
	Domain name	_____
	DHCP	On ___ Off ___
	Auto IP	On ___ Off ___ N/A ___
	UPnP	Enabled ___ Disabled ___ N/A ___

³ Most PCs and most Agilent instruments will use a function called auto-IP to automatically assign an IP address if they are configured for DHCP but cannot connect to a DHCP server.

⁴ Some of Agilent's LAN-enabled instruments may be addressable by hostname via NetBIOS, an older networked PC protocol that is still supported by Windows and works with most LANs.

Step 5: Configure your instruments

Configuration may not be necessary for the latest generation of LAN-enabled instruments. In general, the default configuration of these instruments is compatible with the procedures presented here.

For current-generation instruments with modified LAN configurations or older instruments that require manual configuration, you will need to enter a few quick changes via the front panel or a Web browser. Most LAN-based instruments have a built-in Web server, making it possible to access an instrument's internal Web pages (Figure 5) and, in most cases, view and modify the network configuration parameters as needed.

Making changes via the built-in Web server begins by entering the instrument's IP address into the browser's address box (e.g., <http://192.168.1.200>) and pressing Enter. This should display the instrument's welcome page, which may provide links to other pages. Access the page that displays the current LAN configuration and then modify the instrument's TCP/IP parameters as necessary: this may require changes to the IP address, subnet mask and default gateway.⁵ To complete the process, you may have to save the changes then reboot the instrument by turning power off then on again.

Step 6: Run Agilent Connection Expert

With Steps 1 through 5 completed, you're ready to launch Agilent Connection Expert (Figure 6). Click on the Agilent IO Control icon in the Windows notification area then select Agilent Connection Expert (or click "Refresh All" if Connection Expert is already running). You can now perform additional tasks related to LAN-enabled instruments: add a LAN instrument to the system (mandatory); configure a LAN interface (optional); or communicate with any connected instrument via Interactive IO (optional).

Add a LAN instrument: Whether an instrument resides on a private or site LAN, there are several ways to add the instrument to your test system. You may also use any of these methods to make a change to any instrument that is already part of the system.

When using Connection Expert, the key concept is the "local subnet," which is typically the portion of your intranet connected to the private or non-enterprise side of the nearest router. To prevent disruptions of network traffic beyond the router – and avoid excessively long searches across the entire LAN – Connection Expert can only discover instruments automatically within the local subnet. To communicate with remote instruments (those on the other side of the router) you must be able to specify a hostname or IP address in the LAN Instrument dialog box.

Figure 5. Browser-accessible welcome page for the Agilent 33220A function/arbitrary waveform generator

Welcome to your
Web-Enabled 20 MHz Function/Arbitrary Waveform Generator

Information about this Web-Enabled Instrument

Instrument:	33220A 20 MHz Function/Arbitrary Waveform Generator
Serial Number:	US 0123456
Description:	Agilent 33220A (US 0123456)
Hostname:	a-33220a-23456.lvd.agilent.com
IP Address:	156.140.105.104
VISA TCP/IP Connect String:	TCPIP0::a-33220a-23456::INSTR

Advanced information



⁵ Individual instruments will respond differently to these changes. In most cases the new settings will not take effect until you cycle the instrument's power off then on. Some instruments may change the IP address immediately and you will have to enter the new address into the browser's address box before making additional changes.

- **Local subnet instrument:** When an instrument is on the local subnet, the easiest way to add the instrument to the test system is to ask that Connection Expert discover it. This eliminates the need to specify the instrument's hostname or IP address.
- **Non-local subnet instrument:** After you enter an instrument's hostname or IP address, Connection Expert will try to open a connection to that instrument on the LAN. If it succeeds, it will perform the same bus addressing procedures as it would for a local instrument.

Configure a LAN interface: If you select the LAN interface in the explorer pane, the properties pane will display the current properties for that interface. The properties pane displays the most commonly accessed properties at the top and provides a "More" button that will display additional properties in the lower portion of the pane. Clicking on the Change Properties button will display a dialog box that lets you modify configuration parameters such as interface ID (used by VISA and SICL) and timeout values. The online Help, available from the Help button in each dialog box, gives information on each configuration parameter.

Coexisting with other versions of VISA

Although the VISA API is a standard, each vendor employs different layers beneath the VISA layer to control their hardware. Some have even made enhancements to enable unique features in their application layers. For proper operation, the version of VISA installed on the system's host PC must be compatible with the I/O hardware.

Fortunately, it's possible to perform a side-by-side installation of Agilent VISA and achieve proper I/O operation. For example, you can use Agilent VISA and National Instruments' NI-VISA in the same PC.

The VISA standard requires that visa32.dll, the dynamic-link library that implements the VISA interface, be installed in specific locations. Thus, only one installed implementation (the primary implementation) can fully comply with the standard at one time.

To avoid conflicts, the Agilent IO Libraries Suite gives you the option to install Agilent VISA in side-by-side mode. In this case, Agilent VISA is installed in a secondary location and does not overwrite any other VISA already present on the PC.

After installing Agilent VISA in side-by-side mode (as the secondary VISA) you can use either the Agilent or NI VISA library in your programs. The side-by-side installation allows you to choose which VISA library you link your program against so you can take advantage of the support and features of each vendor's VISA implementation.

If you choose to use Agilent interface hardware in a program linked against NI-VISA, IO Libraries Suite online Help can guide you through the configuration of NI-VISA. This is the easiest way to use your VISA code (linked against the primary VISA) without rebuilding your program.

If you use NI GPIB cards and devices, you don't need to install NI-VISA. Instead, you can simply install NI-488.2 as a driver for these devices and avoid the complications of side-by-side operation. You could then use Connection Expert to configure Agilent VISA to use the NI GPIB card.

Whenever you mix interface hardware from different vendors, it's best to configure each device using the configuration tools from its manufacturer. NI interfaces should be configured with the NI MAX utility prior to use. Agilent interfaces are automatically configured when you install the IO Libraries Suite, but if you add a new interface or decide to change interface properties, use Agilent Connection Expert.

Communicate via Interactive IO: You can use this software utility from within Connection Expert (or from IO Control) to verify communication with instruments via LAN:

- Interactively send commands and view responses without writing program code
- Quickly verify connectivity to an instrument
- Troubleshoot communication problems
- Learn the instrument's command set
- Rapidly prototype commands and check the instrument's responses before you begin writing code

You can start Interactive IO from within Connection Expert in one of three ways: by clicking the *Send commands to this instrument* task in the task guide; by clicking Tools then Interactive IO on the Connection Expert menu bar; or by right-clicking the instrument in the explorer panel and selecting *Send Commands To This Instrument*.

Shaping the future of test systems

LAN technology offers advantages that make it an attractive alternative to GPIB in test systems. However, even as LAN becomes more common in test equipment it will likely coexist alongside GPIB for many years to come.

With LAN ports in most current-generation PCs and many new-generation test instruments, connecting the two should be as simple as plugging a network cable into the ports. Today, it's almost that easy when you apply the libraries and utilities that are part of the Agilent IO Libraries Suite 14 – and follow the quick, six-step configuration process described in this note. Once that process is completed, GPIB, LAN, USB and other standard interfaces are equally easy to use within a test system. What's more, included tools such as Agilent Connection Expert and a set of six I/O utilities make it easy to configure, debug and troubleshoot those connections.

To discover more ways to simplify system integration, accelerate system development and apply the advantages of open connectivity, please visit the Web site at www.agilent.com/find/open. Once you're there, you can also sign up for early delivery of future application notes in this series. Just look for the link "Join your peers simplifying test-system integration."

Glossary

API — application programming interface; a well-defined set of software routines through which an application program can access the functions and services provided by an underlying operating system or a reusable software library

COM — Component Object Model; also called Microsoft COM; allows software developers to create new software components that can be used with an existing application program without modifying the program; an improvement over DLLs for software reuse

Crossover cable — a network cable with its send and receive lines crossed, allowing direct connection of two LAN devices; normal LAN cables are labeled “straight” or “straight through”

DHCP — dynamic host configuration protocol; a method of automatically obtaining an IP address for a LAN-connected device (e.g., PC, router, instrument, etc.)

DDNS — dynamic domain name server; a service that allows a network device to establish its hostname when it connects to the network. This lets other devices use that hostname with DNS to find the device’s IP address and connect to it.

DLL — dynamic-link library; a set of software operations used by other application programs; can be loaded at any time and can serve as a container for a reusable software library that can be shared simultaneously by multiple applications

DNS — domain name server; maps specific names to IP addresses, enabling use of names in place of IP addresses in test programs

Driver — also called an instrument driver; a collection of functions resident on a computer and used to control an instrument (e.g., DMM, oscilloscope, network analyzer); an alternative to SICL and VISA

DUT — device under test; the component, subassembly or product to be measured by the test system

Ethernet — a specific LAN technology that is the dominant implementation of the physical and data link layers; also known as IEEE 802.3

GPIB — General Purpose Interface Bus; the dominant 8-bit parallel I/O connection for test equipment and test systems

HP-IB — Hewlett-Packard Interface Bus; another name for GPIB

Hub — a multi-port LAN device that connects multiple devices together, usually in a star topology

ICS — Internet connection sharing; allows multiple devices to share a single network connection

IP — Internet protocol; requires an address to communicate

IVI — Interchangeable Virtual Instruments; a standard instrument driver model that allows a consistent programming style across instrument models and classes

IVI-COM drivers — also called IVI component drivers; presents the IVI driver as a COM object, preserving the full capabilities of COM-enabled development environments

LAN — local area network

Library — a collection of callable software operations; reusable software functions meant to be used by other programs

MAC — media access control; every LAN device has a unique MAC address

.NET Framework — a platform for application development that provides a large library of operations, encourages software reuse, reduces programmer error and simplifies application development in a Windows environment; its two main components are the common language runtime and the class libraries

NetBIOS — Network Basic Input/Output System; a network configuration protocol that allows Windows computers on ad-hoc networks (those without network controllers such as DNS or DHCP servers) to find and use each others’ resources

Router — a LAN device that joins multiple networks and enables creation of small, private networks

SICL — Standard Instrument Control Library; a modular instrument communications library that works with a variety of computer architectures, I/O interfaces and operating systems; largely superseded by VISA

Subnet — a group of connected network devices; used to partition networks into segments for easier administration

Subnet mask — a setting that accompanies an IP address and defines the boundaries of a subnet

Switch — a LAN device that connects multiple devices to a single LAN line; however, unlike a hub, it preserves full network bandwidth to each device

TCP/IP — Transfer Control Protocol and Internet Protocol; the two standards that provide the data communication foundation of the Internet

USB — Universal Serial Bus; designed to replace the RS-232 and RS-422 serial buses used in PCs

VISA — Virtual Instrument Software Architecture; sometimes called VISA-C; a common foundation for system software components, including instrument drivers, virtual front panels and application software; consists of a vendor-independent set of instrument communication operations that work across different I/O interface technologies

VISA COM — provides the services of VISA in a COM-based API; a subset of VISA in terms of I/O capabilities but includes some services not available in VISA

VXI — VME extensions for instrumentation; a standard, open architecture for modular test instrumentation and systems

VXIplug&play — a popular driver technology for all types of instrumentation; provides a consistent programming style across instruments; some VXIplug&play drivers include virtual front panel technology that allows development environments to provide extra help and visual guidance for operating an instrument

Related literature

The Agilent IO Libraries Suite product documentation provides additional information about I/O configuration:

- *Agilent IO Libraries Suite E2094N: Getting Started*
(pub no. E2094-90004)
<http://cp.literature.agilent.com/litweb/pdf/E2094-90004.pdf>
- *Agilent USB/LAN/GPIB Interfaces: Connectivity Guide* (pub no. 5188-5724)
<http://cp.literature.agilent.com/litweb/pdf/5188-5724.pdf>

The other notes in this series provide additional information about the successful use of LAN in test systems:

- *Using LAN in Test Systems: The Basics*, AN 1465-9 (pub no. 5989-1412EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1412EN.pdf>
- *Using LAN in Test Systems: Network Configuration*, AN 1465-10 (pub no. 5989-1413EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1413EN.pdf>
- *Using LAN in Test Systems: PC Configuration*, AN 1465-11 (pub no. 5989-1415EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1415EN.pdf>
- *Using USB in the Test and Measurement Environment*, AN 1465-12 (pub no. 5989-1417EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1417EN.pdf>
- *Using SCPI and Direct IO vs. Drivers*, AN 1465-13 (pub no. 5989-1414EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1414EN.pdf>

Other Agilent application notes provide additional hints that can help you develop effective test systems:

- *Creating a Wireless LAN Connection to a Measurement System*, AN 1409-3 (pub no. 5988-7688EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-7688EN.pdf>
- *Introduction to Test System Design*, AN 1465-1 (pub no. 5988-9747EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9747EN.pdf>
- *Computer I/O Considerations*, AN 1465-2 (pub no. 5988-9818EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9818EN.pdf>
- *Understanding Drivers and Direct I/O*, AN 1465-3 (pub no. 5989-0110EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-0110EN.pdf>
- *Choosing Your Test-System Software Architecture*, AN 1465-4 (pub no. 5988-9819EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9819EN.pdf>
- *Choosing Your Test-System Hardware Architecture and Instrumentation*, AN 1465-5 (pub no. 5988-9820EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9820EN.pdf>
- *Understanding the Effects of Racking and System Interconnections*, AN 1465-6 (pub no. 5988-9821EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9821EN.pdf>
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