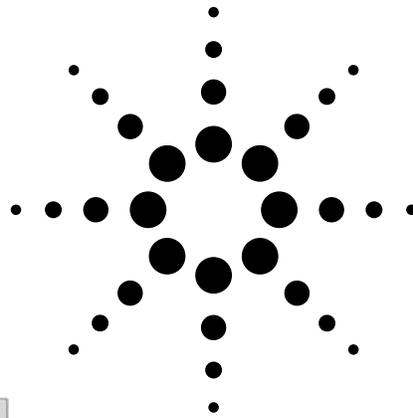


Next-generation Test Systems

Advancing the Vision with LXI

1465-16



LAN eXtensions for Instrumentation (LXI) is a next-generation measurement platform based on widely used standards such as Ethernet, TCP/IP, Web browsers and IVI-COM drivers. LXI combines the measurement functionality and PC-standard input/output (I/O) connectivity of standalone instruments with the modularity and compact size of plug-in cards—but without the size or cost of a cardcage.

With LXI, engineers will be able to easily leverage or migrate measurement capabilities, test routines and system software from standalone instruments to their modular equivalents. The LXI standard enables long-lived instrument and

system implementations by relying on the stability of computer and networking standards, and by freeing system developers from proprietary standards that often fall behind in performance and functionality.

Advancing the Vision with LXI provides an introduction to LXI, presents its advantages, and outlines usage models that expand the reach and capabilities—and perhaps the definition—of test systems. This note also describes LXI's role within an approach we call Agilent Open, which simplifies system development through system-ready instrumentation, PC-standard I/O and open software environments.

Table of contents

Defining the core challenge	2
Taking the first steps	2
Extending LAN for instrumentation	3
Ensuring excellent performance	3
Defining three classes	3
The LXI Consortium	3
Solving the tough challenges	4
Synchronization and timing	4
Envisioning the future	5
Simplifying system development with Agilent Open	6
Shaping the future of test systems	6
Appendix A: Leveraging the power of LAN technology	7
Appendix B: Enabling precise timing with IEEE 1588	7
Appendix C: Defining synthetic instruments	8
Appendix D: Reducing the cost of system software	9
Glossary	10
Related literature	11



Agilent Technologies

Defining the core challenge

When creating test systems, engineers face the ongoing need to reduce the time and expense of system development, integration and deployment. Many have requested five specific solutions to these problems:

- Eliminate specialized interfaces and make it easier to use the standard I/O ports on a PC
- Make test equipment more modular but eliminate the costly cardcage and Slot 0 controller
- Reduce the footprint of deployed systems
- Provide software, drivers and utilities that simplify system set up
- Make it easier to leverage software from R&D to manufacturing—and ensure measurement integrity after the transition to manufacturing

Some have highlighted another issue: test systems remain in service longer than the lifetime of most backplanes and interfaces. Computer backplanes—ISA, EISA, VME, PCI, Compact PCI—change every few years but usually offer little or no backward compatibility. The instrumentation versions—VXI, PXI—have the same drawback. To compound the problem, standardized test and measurement (T&M) interfaces such as GPIB and MXI have fallen short of both the increased speed and widespread adoption of LAN and USB. Instead, new GPIB or MXI cards must be developed and purchased whenever computer architectures change.

To help test system engineers overcome these issues, Agilent is leading the way to a new vision for future test systems. The vision starts with full-fledged instruments packaged in small, easy-to-integrate modules that utilize PC-standard I/O. It also includes hardware and software building blocks that enable rapid arrangement and rearrangement of “synthetic” instruments that increase a system’s flexibility while reducing its size and cost.

Taking the first steps

Agilent was one of the first T&M manufacturers to utilize PC-standard technologies, adding Web-based interfaces and LAN ports to a variety of instruments. These enhancements have been well received because virtually every current-generation PC is equipped with a Web browser and a LAN port.

LAN is gaining momentum in T&M because it has several inherent advantages that surpass the limitations of most parallel and serial interfaces. For example, LAN can handle an unlimited number of nodes and provides long distance inter-device connectivity. It also includes TCP/IP error checking and fault detection—and these functions typically won’t interfere with throughput rates.¹ Better still, LAN enables automatic device discovery, addressing, asset management and network management.

The LAN interface becomes “GPIB easy” when used with innovative software products such as the Agilent IO Libraries Suite (E2094N), which simplifies connections between PCs and LAN-enabled instruments. Looking to the future, adding the enhancements defined by the LXI standard will let test engineers take even greater advantage of this powerful I/O connection.

Figure 1. Current-generation instruments such as the Agilent 34980A switch/measure unit include LAN, USB and GPIB interfaces



¹ This is especially true if the test system uses a dedicated network. To learn more about creating private networks for test systems, please see Agilent Application Note 1465-10

Extending LAN for instrumentation

The LXI standard is the next logical step in the evolution of LAN-based instrumentation. It includes “box” instruments, full-fledged instrument modules and instrument “building block” modules. To maximize both device interoperability and user satisfaction, the LXI specification clearly defines the minimum capabilities of compliant instruments. It does this by leveraging established standards such as IEEE 802.3 (Ethernet), TCP/IP, Web browsers, XML, IVI-COM drivers and IEEE 1588.

Ensuring excellent performance

The LXI standard defines instrument-specific requirements meant to ensure reliable, accurate operation in a system environment:

- Cooling
- Triggering
- Interrupt handling
- Mechanical interfaces
- Software interfaces
- Electromagnetic and radio-frequency interference
- Network routing and switching
- Discovery
- Synchronization across multiple devices

These requirements also enable reliable calibration of LXI modules, whether they are self-contained instruments or functional building blocks. Calibration and accuracy are further enhanced by the absence of a cardage, which may cause cooling and interference problems.

Defining three classes

The LXI standard defines three types of instruments that can be readily mixed and matched within a test system.

Class C: These are standalone or bench-type instruments that replace GPIB with LAN and harness the full breadth of LAN’s capabilities. They also utilize a Web interface (with XML) for instrument set-up and data access. To simplify programming, Class C instruments provide an IVI driver API (application programming interface).

Class B: These devices are designed to enable distributed measurement systems. They meet Class C requirements and include IEEE 1588 synchronization (please see Appendix B).

Class A: Devices in this category satisfy Class C and B requirements and add two more attributes: a fast hardware trigger bus and an operational model for synthetic instruments (please see Appendix C).

Physically, standalone LXI instruments may be full- or half-rack width and tall enough to accommodate the front-panel display and keypad. Modular LXI instruments (without a display or keyboard) are typically half- or full-rack width and just 1U or 2U high. All signal connections—inputs and outputs—are on the front panel; power and I/O connections are on the back.

The LXI Consortium

The LXI Consortium is a not-for-profit (501c3) corporation and the key participants are leading companies in the T&M industry. Its driving goal is to ensure a consistent, positive user experience through hardware and software interoperability. The consortium aims to achieve this goal by developing, supporting and promoting the LXI standard.

The formation of the consortium was driven by the realization that several companies were developing LAN-based measurement modules. Ultimately, many agreed that it made sense to abandon multiple incompatible approaches and instead combine their efforts into an industry standard that will better serve the present and future needs of T&M customers.

To learn more about the LXI Consortium, please visit the Web site at www.lxistandard.org.

Figure 2. LXI devices reduce the size and footprint of test systems



Solving the tough challenges

Through the standards it embraces and the extensions it adds, LXI offers four powerful advantages that address the needs of system developers.

Greater flexibility: LXI's modular approach makes it easy to mix and match modules that provide the exact functionality required for each system or application. LXI extends this concept further in the case of RF instruments: Class A building-block modules such as digitizers and down-converters can be quickly reconfigured via software commands to create synthetic instruments that provide the capabilities of a spectrum analyzer, signal generator, waveform digitizer and so on.

Lower costs: LXI can reduce the time and money spent on measurement hardware, software development and system integration. For example, system creators can purchase only those modules needed for testing—and forego the expense of a cardcage, Slot 0 controller and proprietary interface. LXI lets software developers leverage their existing investments: test routines written for a Class C instrument will also work with its equivalent, faceless Class A or B module. System integration is also faster because LXI utilizes the host PC's LAN interface and Web browser: no time is spent installing and configuring a GPIB or MXI interface.

Smaller footprint: In some applications, a test specification may demand multiple instruments of the same type. LXI makes it possible to equip a system with, for example, multiple faceless, 1U digitizers or arbitrary waveform generators that consume much less rack space than their stand-alone equivalents but still provide the same capabilities and accuracy.

Robust security: The decision to use LAN for system I/O makes it easy to create a private, protected LAN that can shield a test system from potential security risks. The standard capabilities of most Windows® PCs and many low-cost networking products enable two viable approaches: one is built around a router (with built-in firewall) and the other is based on a PC equipped with two LAN cards. For a detailed description of both approaches, please see Agilent Application Note 1465-10.

Synchronization and timing

Measurement accuracy depends on precise synchronization of every device in a test system. While LAN technologies are excellent for communication and control, their timing specifications are not stringent enough for measurement applications—especially in distributed systems. The IEEE 1588 standard, through its precision time protocol (PTP), addresses this shortcoming.

The underlying technique—developed by Agilent Labs—relies on system devices that contain real-time clocks and, via the PTP, enables system-wide synchronization in the sub-microsecond range. IEEE 1588 is applicable to all systems that communicate via local area networks such as Ethernet that support multicast messaging.

To learn more, please see Appendix B on page 7 and visit the National Institute of Science and Technology (NIST) Web site at iee1588.nist.gov.

Envisioning the future

The advantages of LXI enable a variety of compelling new usage models that expand the reach and capabilities—and perhaps the definition—of test systems. The following examples describe several possible scenarios that can be achieved with LXI.

Easier transitions: One of the biggest challenges in a new product's lifecycle is the transition of its test system from development to manufacturing. With LXI, this transition can be achieved much more easily and cost effectively than with cardcage-based systems.

As an example scenario, engineers can utilize LXI Class C instruments during the R&D phase, using the display and keypad to quickly access a wealth of measurement and analysis capabilities. In manufacturing, a system containing the same LXI instrument in a faceless, modular form can use the software and test routines developed with the stand-alone instrument. Unlike VXI or PXI, this ensures instrument-equivalent precision and performance while also eliminating the overhead of a cardcage and proprietary interface.

Rapid reconfiguration: LXI-based synthetic instruments reduce system size and cost by utilizing multi-purpose modules—digitizers, waveform generators, upconverters, downconverters and more—that can be combined to create traditional instruments such as spectrum analyzers, signal generators and oscilloscopes. These fundamental building blocks depend on PC software that dynamically aggregates and “synthesizes” different measurement tasks.

As an example, an RF downconverter LXI module could be used for spectral measurements in one test sequence and then be reconfigured for network measurements in another. To create the stimulus signal for network analysis, simply adding a different LXI upconverter makes it easy to change the output frequency range without having to purchase an entirely new signal generator. Reducing the redundancy—and increasing the utilization—of these fundamental hardware elements helps trim the size and cost of test systems.

Enhanced throughput: The flexibility of LXI provides two ways to boost system throughput. In one scenario, software routines can be run within the LXI module, perhaps performing basic analysis functions and simply passing results (rather than data blocks) to the host PC. If necessary, advanced routines can be run in the PC, which will typically have greater computational power than most LXI modules. In the other scenario, peer-to-peer communication between LXI modules can be used to coordinate their activities, eliminating bottlenecks that could occur if all messages were handled by the host PC.

Multi-site collaboration: When a geographically distributed team is working on a one-of-a-kind prototype, LXI makes it possible for team members to make measurements from their desk, wherever it may be. To help ensure system security, any LXI instrument that contains an Intel processor and a Windows operating system can run a firewall application that shields the test system from unauthorized access. Typically, most LXI devices will be part of a system that has a dedicated LAN, but remote users can gain secure access to the system through its host PC.

Synchronized systems: With the timing capabilities of Class A and B LXI devices, it's possible to synchronize multiple systems within a building, between sites or around the world. This is enabled by IEEE 1588, which has the ability to achieve sub-microsecond accuracy among devices located anywhere on the network. Possible applications include trend and cause-and-effect analyses driven by data from multiple instruments or systems. By time stamping all of the data, it can then be correlated and analyzed in one or more computers to identify trends or cause-and-effect relationships.

Simplifying system development with Agilent Open

With system-friendly capabilities and PC-standard I/O, LXI-based instruments are the next step in the evolution of an approach we call Agilent Open. This concept includes an integrated set of system components—hardware and software—that enhances test system creation in three ways:

- **Accelerates development** by providing system-ready instruments that are optimized for automated testing.
- **Simplifies integration** by including PC-standard I/O interfaces that make it easy to connect instruments and PCs.
- **Reduces the need for writing new programs** by supporting software that ranges from Microsoft® Excel to Agilent VEE Pro to Visual Studio® .NET and other open application development environments.

With Agilent Open, a system can include multiple types of instruments—GPIB, VXI, PXI, LAN, USB—in various formats from multiple vendors (Figure 3). Getting these devices to work together requires less effort than in the past:

- The Agilent IO Libraries Suite makes it easy to integrate a system
- Standard IVI-COM drivers work in multiple programming languages
- Standard instrument drivers work across the major I/O types
- PC-standard tools such as .NET objects provide leverage that reduces the amount of code developers have to write

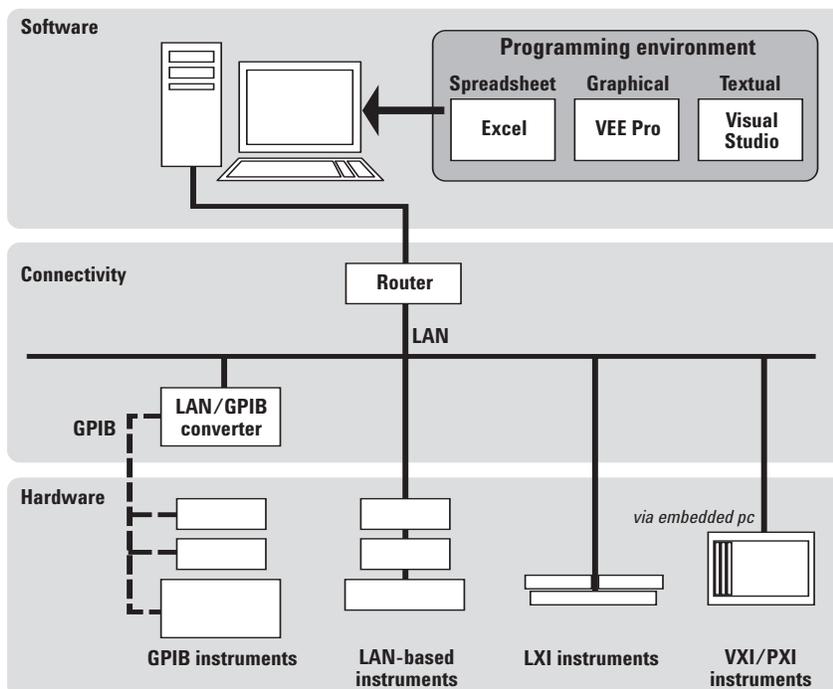
By relying on a wide range of industry standards, Agilent Open enhances system longevity and opens the door to future advances in measurement, connectivity and programming.

Shaping the future of test systems

Today, Agilent is leading the way in migrating test systems to the advanced capabilities of LAN. We're continually introducing new additions to what is currently the industry's largest portfolio of LAN-enabled instruments. At the same time, we're also protecting your investment in GPIB instruments by offering devices such as the Agilent E5810A LAN/GPIB gateway and the 82357A USB/GPIB interface.

To discover more ways to accelerate system development, simplify system integration and apply the advantages of open connectivity, please visit the Agilent Open 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."

Figure 3. The strength of Agilent Open is its ability to simplify system development, integration and deployment



Appendix A: Leveraging the power of LAN technology

LAN is the logical choice for instrumentation I/O. Because most current-generation PCs have built-in LAN ports, the computing portion of a test system often needs only minimal physical configuration. LAN also has a cost advantage: the prices of cables, interface cards, hubs, routers, switches, wireless access points and so on are low and continue to fall.

These advantages come from the computer industry's substantial investment in networking technology. A big part of that investment is in brainpower: the computer industry employs far more design engineers than the T&M industry. Since 1980, their efforts have boosted Ethernet speeds by three orders of magnitude, from 10 Mb/s to 10 Gb/s. Even more impressive, they have preserved backward compatibility as speeds have increased. In comparison, T&M-standard interfaces such as GPIB and MXI have not kept pace with the speed, capabilities or compatibility of LAN.

Rather than inventing yet another proprietary standard, it makes far more sense to ride the wave of LAN innovation. By leveraging PC-standard technologies, T&M equipment makers can focus on what they do best, which is provide great measurements.

Appendix B: Enabling precise timing with IEEE 1588

Traditionally, measurement systems have used a centralized architecture that keeps instruments and the host computer located near each other. In this type of system, timing constraints can be met by careful attention to programming and the application of communication technologies that have deterministic latency.

Today, many measurement applications are putting increasingly tight timing requirements on test systems. Also, a growing number of applications require systems that use distributed architectures, placing devices in widely dispersed locations. Standard networking technologies are well suited to distributed systems; however, these technologies utilize timing specifications that are typically not stringent enough for measurement applications. This has led to the development of the IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

The IEEE 1588 protocol is applicable to systems that communicate via local area networks such as Ethernet that support multicast messaging. Even though the protocol can achieve sub-microsecond synchronization, it puts minimal burden on a system's net-

working and computing resources by utilizing the real-time clocks contained in PCs, instruments, smart sensors and other system devices.

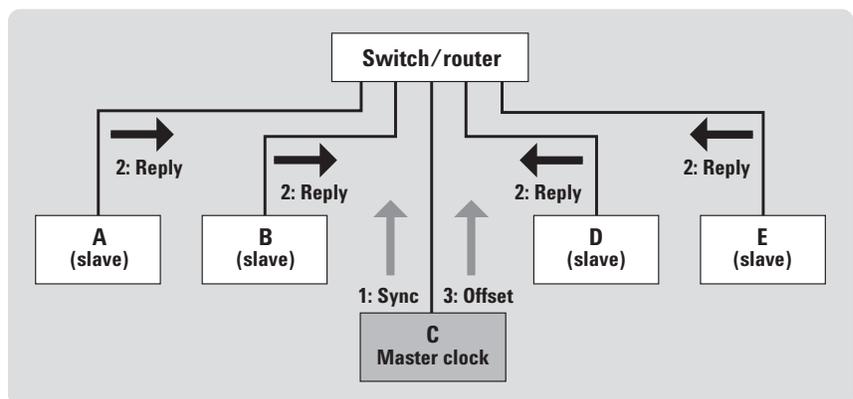
When the synchronization process begins, those devices identify the most accurate clock in the system and assign it the role of master clock. Figure 4 will help illustrate the rest of this elegantly simple process.

1. The master clock sends a sync pulse and the current time to every other device on the network. All slaves set their clocks to the master time.
2. Each slave sends a time-stamped reply to the master. The master calculates the offset between the original transmission time of the sync pulse and the various reception times.
3. The master sends an offset value to each slave, which adjusts its clock to compensate for the difference between the master's sync pulse and its reception time at the slave.

After this initial alignment, periodic sync pulses are enough to keep the slaves precisely synchronized to the master clock. The result is a test system that can address the most demanding distributed measurement applications.

For more information about IEEE 1588 and its operation, please visit the Web site at ieee1588.nist.gov.

Figure 4. In an IEEE 1588-enabled network, a simple process ensures sub-microsecond synchronization between all devices



Appendix C: Defining synthetic instruments

In the mid 1990s, the U.S. Department of Defense (DoD) assigned the U.S. Navy the task of developing new types of automated test systems (ATS) for the testing of avionics and weapons systems in the factory, on the front lines and anywhere in between. The project has six driving goals:

- Reduce the total cost of ownership of ATS
- Reduce the time to develop and deploy new or upgraded ATS
- Reduce the physical footprint of each system
- Reduce the logistics footprint via decreased spares, support systems and training
- Provide greater flexibility through systems that are interoperable among U.S. and allied services
- Improve the overall quality of testing

These are ambitious goals but equipment manufacturers, defense contractors and the DoD believe they can be achieved over time by applying advances in commercial technologies.

The greatest progress toward these goals may come from the use of synthetic instruments (SI). According to the Synthetic Instruments Working Group,² a synthetic instrument is a reconfigurable system that links a series of elemental hardware and software components via standardized interfaces to generate signals or make measurements using numeric processing techniques. The key word is reconfigurable: the elemental blocks can be arranged and rearranged via software commands to emulate one or more traditional pieces of test equipment.

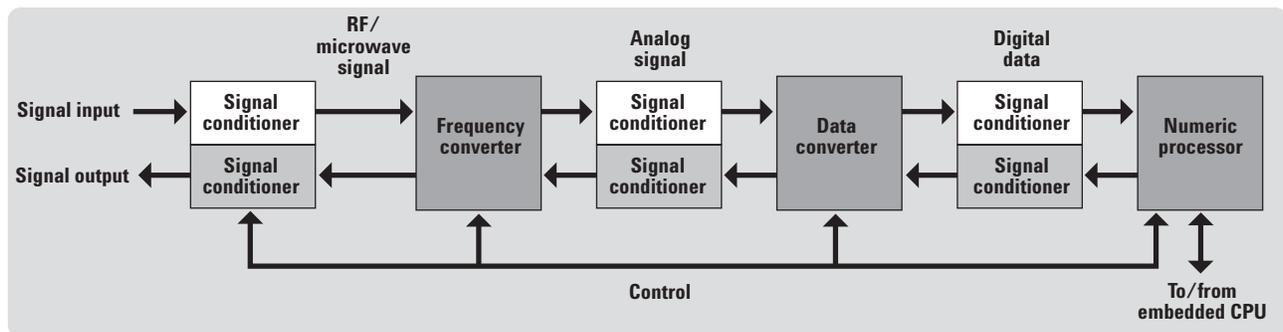
To make it work, an SI will contain as many as four major components: signal conditioners, frequency converters, data converters and numeric processors. The basic block diagram shown in Figure 5 describes most microwave instruments, including spectrum analyzers, frequency counters, network analyzers and signal generators.

Unlike general purpose instruments, which are optimized to perform one task (e.g., spectrum analysis or signal generation), the synthetic instrument architecture is optimized to provide greater efficiency in ATS by reducing redundant elements such as the digitizers and downconverters found in multiple instruments within a system.

The DoD expects these SI modules to come from a variety of vendors, enabling easy mixing and matching as requirements change or modules become obsolete. What's more, any substitution of modules should require only minimal changes to the core system software.

Agilent plans to develop SIs in the LXI modular format, which leverages the ongoing advancement of LAN technology. The benefits of the Agilent Open approach will also help accelerate the development and deployment of new or upgraded systems.

Figure 5. Basic architecture of an RF/microwave synthetic instrument



² Includes joint participation of the DoD, prime contractors and suppliers.

Appendix D: Reducing the cost of system software

Cutting the time and expense required to create and maintain system software will dramatically shrink the cost of present and future test systems. Agilent is addressing this opportunity in two ways.

Work where you're most comfortable

Agilent strives to help test engineers use whichever type of software they prefer: a spreadsheet, a textual programming language or a graphical development environment. One enabling technology is the standardized IVI-COM drivers provided with Agilent instruments: these make it possible for developers to work in Agilent VEE Pro or any other T&M-specific language that embraces industry standards. IVI-COM drivers also enable programming in Visual Studio .NET languages such as Visual C++, Visual Basic and C#. This lets developers write programs in multiple languages then mix and match those programs as necessary to create a larger test program—and do so knowing the IVI-COM drivers will work consistently.

Another enabler is Agilent T&M Toolkit, which extends and enhances Visual Studio .NET for measurement applications. The toolkit includes a suite of integrated, easy-to-use software tools and components such as project wizards, APIs, class libraries, widgets, graphs and drivers. For developers, the combination of T&M Toolkit and Visual Studio creates an environment that simplifies the process of incorporating tests and measurements into custom applications.

Increase your measurement flexibility—and consistency

Taking a broader view, the software utilized in a test system also includes the code within each instrument: firmware, core measurement functions, individual measurement routines, and downloadable measurement suites or “personalities.” Today, many Agilent instruments use industry-standard Microsoft operating systems, enabling future developments such as “measurement software” modules that will run in the original instrument as well as a PC and, potentially, other Windows-based instruments. The ability to use a preferred or standardized measurement across multiple hardware platforms lowers the cost of creating a test system and also ensures consistent, comparable results in R&D, design verification and manufacturing.

Accelerate system development

The use of industry standard software is a key part of the Agilent Open approach to system development. It saves time by letting you use software you already know—and communicate with instruments you already have. In the future, it will reduce both time and effort by letting you choose the measurement software you need and use it in either an instrument or a PC, as needed. With the ability to make identical measurements in R&D, manufacturing and elsewhere, you'll also spend less time troubleshooting results that don't match. All in all, it's an approach that addresses the most costly portion of any test system—now and in the future.

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

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 host name when it connects to the network. This lets other devices use that host name 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

Gateway — a hardware device that connects devices that use different standards and protocols (e.g., LAN to GPIB)

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

IEEE 1588 — a standard that enables very precise synchronization of all devices in a test system network

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 callable software operations; reusable software functions meant to be used by other programs

LXI — LAN eXtensions for Instrumentation; an instrumentation platform based on widely used standards such as Ethernet, TCP/IP and IVI-COM drivers; small, faceless modules designed for use in PC-based automated test systems

.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

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

SNMP — Simple Network Management Protocol; a standard TCP/IP protocol that enables monitoring and mapping of network availability, performance and error rates

Synthetic instrument — a collection of hardware and software modules that can be linked together to emulate the capabilities of a standalone instrument

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

UPnP — Universal Plug and Play; a networking architecture that ensures compatibility between devices, software and peripherals; not the same as Plug and Play or *VXIPlug&Play* drivers

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

Related literature

The 1465 series of application notes provides 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 I/O vs. Drivers*, AN 1465-13 (pub no. 5989-1414EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1414EN.pdf>
- *Using LAN in Test Systems: Applications*, AN 1465-14 (pub no. 5989-1416EN)
<http://cp.literature.agilent.com/litweb/pdf/5989-1416EN.pdf>
- *Using LAN in Test Systems: Setting Up System I/O*, AN 1465-15 (pub no. 5989-2409)
<http://cp.literature.agilent.com/litweb/pdf/5989-2409EN.pdf>

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

- *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>
- *Maximizing System Throughput and Optimizing System Deployment*, AN 1465-7 (pub no. 5988-9822EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9822EN>
- *Operational Maintenance*, AN 1465-8 (pub no. 5988-9823EN)
<http://cp.literature.agilent.com/litweb/pdf/5988-9823EN>

www.agilent.com



Agilent Email Updates

www.agilent.com/find/emailupdates

Get the latest information on the products and applications you select.



Agilent Open

About Agilent Open

Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent combines a broad range of system-ready instruments, open industry software, PC-standard I/O and global support to accelerate test system development. For more information, see:

www.Agilent.com/find/Open.

By internet, phone, or fax, get assistance with all your test & measurement needs

Online assistance:
www.agilent.com/find/assist

Phone or Fax

United States:

(tel) 800 829 4444
(fax) 800 829 4433

Canada:

(tel) 877 894 4414
(fax) 800 746 4866

China:

(tel) 800 810 0189
(fax) 800 820 2816

Europe:

(tel) (31 20) 547 2111
(fax) (31 20) 547 2390

Japan:

(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Korea:

(tel) (82 2) 2004 5004
(fax) (82 2) 2004 5115

Latin America:

(tel) (650) 752 5000

Taiwan:

(tel) 0800 047 866
(fax) 0800 286 331

Other Asia Pacific Countries:

(tel) (65) 6375 8100
(fax) (65) 6836 0252
(e-mail) tm_asia@agilent.com

Product specifications and descriptions in this document subject to change without notice.

Microsoft, Windows and Visual Studio are U.S. registered trademarks of Microsoft Corporation.

© Agilent Technologies, Inc. 2006
Printed in the USA May 3, 2006
5989-2802EN



Agilent Technologies