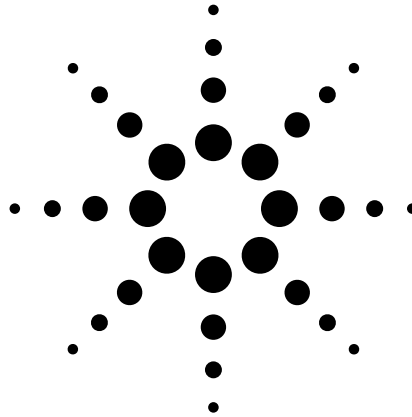# 10 Good Reasons to Switch to LXI

Key advantages that enable better systems

Application Note 1465-21

The vision behind LAN eXtensions for Instrumentation (LXI) is simple: help you conquer the challenges of product testing without overloading your budget or your team. By specifying the interaction of proven, widely used standards such as Ethernet, LXI enables fast, efficient and cost-effective creation and reconfiguration of test systems.

10 Reasons to Switch to LXI is the second in a series of application notes that will help you make the transition to LXI. This note describes 10 key attributes that make LXI a good choice for your next test system, whether you choose to use LXI alone or within a hybrid combination of LXI and GPIB, VXI or PXI.

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Agilent Technologies

Reason 1: Ease of use

More than 30 years after its creation, GPIB remains popular due to its ease-of-use and robustness. Today, LXI meets or beats GPIB on both counts thanks to several advanced features and functions.

Harnessing Ethernet

Admittedly, Ethernet is a fairly complex standard. However, LXI includes a few key elements that make it easy to use for system developers.

Physical layer: To help ensure successful instrument interaction, the LXI standard specifies automatic negotiation of LAN transmission speed and duplex communication. The standard also recommends Auto MDIX, a feature that enables the use of either straight-through or crossover LAN cables in direct controller-to-instrument or peer-to-peer connections. The instrument automatically adjusts to the existing cable and its communication counterpart.

Network (IP) layer: LXI instruments support automatic IP configuration through a DHCP server (often available in managed corporate networks and in cable/DSL routers) or through dynamic configuration of local addresses (typically used in small or ad-hoc networks). LXI also recommends support for DNS, which instruments can use to publish their host name through a DNS server (another feature usually available in corporate networks).

Application layer: LXI-compliant instruments support the VXI-11 protocol (based on remote procedure calls) for automatic discovery of new instruments and identification through the *IDN? query.

Enabling easy interaction

A few noteworthy instrument control features help LXI surpass GPIB in ease-of-use. For example, LXI devices include a built-in Web server to enable configuration and troubleshooting. In many Agilent LXI products, the instrument page also allows interactive instrument control, a capability that can be very useful during system configuration and deployment.

Making programming more efficient

For programmatic control, you can send ASCII-based SCPI commands to an instrument or use IVI-COM instrument drivers. Recommended by the LXI standard, IVI-COM drivers are based on the widely used Microsoft® COM architecture and work with today's most popular test-software environments. These object-oriented drivers use a hierarchical API, making it easy to utilize the advanced features of modern, object-oriented environments. One key example is easy navigation through a driver's hierarchy of functions and simplified coding via autosuggestion and autocompletion.

Simplifying physical integration

The LXI standard also includes an optional mechanical specification that simplifies the integration of modules within system racks. Compliant modules are full- or half-rack wide and typically 1U to 4U high. The standard also specifies that signal input and output connectors (and status lights) are placed on the front of the module while power, Ethernet, triggering and other control connectors are placed on the rear.
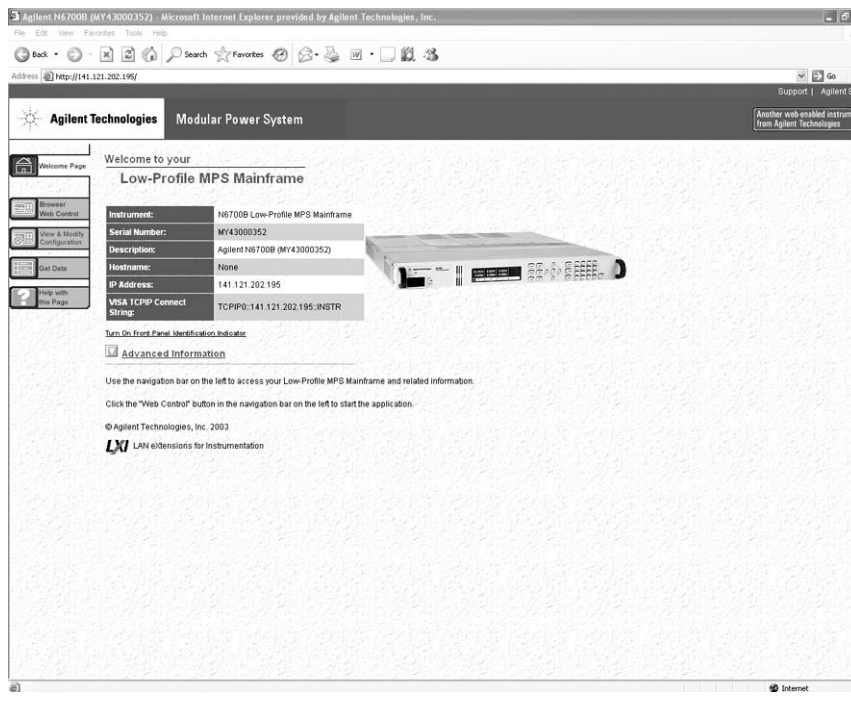

Figure 1. LXI-compliant products support device configuration through a standard browser— and many Agilent products also provide interactive control and monitoring

Reason 2: Flexibility

LXI-compliant instruments provide new levels of flexibility in hardware selection, product testing, software reuse, instrument communication and even organizational responsiveness.

Addressing multiple testing needs

The LXI standard spans classic instruments, faceless modular instruments, and functional building-block modules (synthetic instruments or SIs). Broad-based support from major instrumentation vendors (see sidebar) means you will be able to address your full range of testing needs—source, measure, RF, power—with just one architecture. Even when space is at a premium, you don't have to sacrifice functionality, accuracy or performance.

Even better, you won't have to sacrifice your existing test assets. To help you create hybrid systems that use LXI-based devices alongside GPIB, PXI and VXI hardware, Agilent offers a range of I/O gateways and converters. Bringing your system software forward to work with LAN requires nothing more than simple address changes.

Testing all along the lifecycle

The various forms of LXI devices also make it easier for you to test your product across its entire lifecycle. In some cases, a classic instrument can be used on the bench while an equivalent faceless instrument can be used in a rack in the final test system—without rewriting the system software. This concept can be extended with synthetic instruments: through the necessary SI hardware and software modules, a few functional building blocks can do the work of multiple RF/microwave instruments.[1]

Working independently

With their embedded processors, many of today's test instruments have enough computing power to carry out measurement tasks on their own, freeing the system controller for other tasks. LXI uses this power to provide greater flexibility in communication, too: instruments can communicate without arbitration through the system controller. Instead, they can use TCP for peer-to-peer communication and UDP for multicast (one-to-many) messages.

Boosting team efficiency

LXI also helps you address future organizational needs. Test-system experts are becoming scarce in many organizations and can't be everywhere at once—onsite, offshore or anywhere in between. With LXI, you can place test systems virtually anywhere on your intranet, enabling your team to perform centralized troubleshooting, remote monitoring and more.

The LXI Consortium

The consortium is a not-for-profit corporation initially established by Agilent Technologies and VXI Technology, Inc. Its primary purpose is to promote the development and adoption of the LXI standard as an open, accessible standard that identifies specifications and solutions relating to the functional test, measurement and data acquisition industries. The Consortium is open to all test and measurement companies—over 40 are now members—as well as industry professionals, system integrators and government representatives. For more information about the consortium, please visit **www.lxistandard.org.**

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1 See Reason 10, Synthetic instruments

Reason 3: Modularity and scalability

Scalability means buying just what you need when you need it—and being able to easily expand the system in the future. With LXI, scalability follows from modularity. This truly modular architecture lets you freely mix and match different types of measurement resources and add measurement channels, digital I/O lines, switches and signal sources as you go.

In PXI and VXI, if a cardcage is filled, the addition of just one more device to the system requires the addition—and additional cost—of another card-cage. Because LXI modules don't require a cardcage, there is no hard limit to the number of devices you can add to a system. In practice, you will instead be limited by factors such as rack space and the number of ports available on a hub or router.

Reason 4: Performance

Test-and-measurement interfaces such as GPIB and MXI are challenged by the need for increasing bandwidths and faster data-transfer rates. One key advantage of LXI is its ability to leverage ongoing innovations in Local Area Networks that satisfy the need for speed.

Moving more megabytes

With a Fast Ethernet connection (IEEE 803.2u, 100 Mb/s), the maximum payload data rate is approximately 12.5 MB/s. Gigabit Ethernet (IEEE 802.3z), which is recommended by the LXI specification, boosts top-end performance by a factor of ten to approximately 125 MB/s.[2] Looking ahead to 10-Gb Ethernet, LXI will be able to surpass the performance of VXI 3.0 (160 MB/s). The backward compatibility of the various Ethernet standards is an added bonus that contributes to system longevity.

Raw network speed isn't the only consideration: simultaneous communication on any network can cause degradation in performance due to collisions and retransmission. To avoid or limit this effect, we recommend the creation of a local subnet dedicated to the test system.

Accelerating system throughput

Other aspects of LXI enhance performance by enabling faster system throughput. For example, LXI makes it possible to build high-speed distributed systems comprised of intelligent instruments that can communicate with each other and operate in parallel. Devices stay synchronized through the IEEE 1588 timing standard,[3] LAN-based triggers, peer-to-peer and multicast messaging, and a hardware trigger bus. IEEE 1588 also accelerates throughput via time-based triggering, which initiates instrument operations at a specific time rather than after a trigger or command.
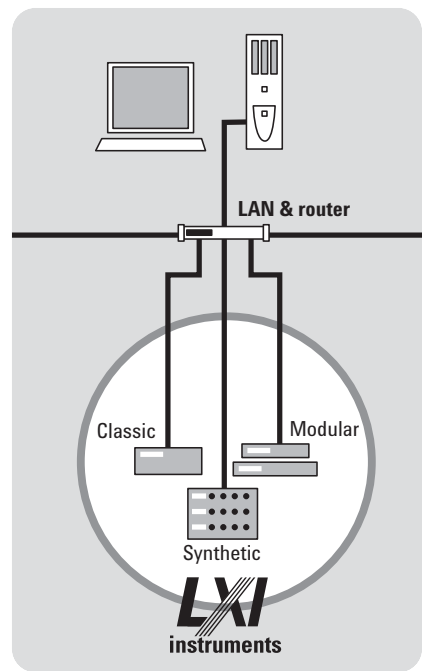

Figure 2. Whether the LAN links are 1-Gb or 100-Mb Ethernet, all can co-exist without affecting system performance.

2 Assuming IPv4 and maximum frame size, the bandwidth remaining for application data is about 95% of the transmission rate.

3 See Reason 8, Synchronization through IEEE 1588.

Reason 5: Distributed applications

Unlike cardcage-based systems, LXI modules can be easily distributed in a test rack, across a lab or throughout a building. This allows you to place instruments where they can best meet the needs of each measurement or application. Examples include the monitoring systems used in environmental applications, power generation and the process-control industry. Another intriguing example is testing of wireless base stations: protocol test equipment can be placed near or inside base stations located many miles apart.

With LXI, these solutions can be designed using the same instruments you would use for local applications and rack-based systems. There is no need to create custom gateways—remote access comes without extra effort. Using your corporate intranet or the public Internet, large distances can be bridged easily and the connection is transparent to the end user.

Ethernet is also widely available in urban areas through cable or DSL modems or wireless LAN hotspots, and in rural areas through wireless IP services based on GPRS or UMTS. These services offer different data rates, but all have one thing in common: usage charges are often based on either data traffic or a flat rate rather than connection time. This allows a remote system to be online all the time without cost penalty.

Of course, security is a concern for any application that requires a connection outside your secure, well-controlled corporate network. Rest assured that solutions designed for the IT world also work with LXI. You can utilize routers that include security features such as access filtering based on MAC or IP addresses, WLAN encryption and so on. If a distributed application needs to access the public Internet, you can use a virtual private network (VPN) to send IP packets securely, encrypted through IPsec or other encryption protocols.

Reason 6: Longevity

In general, test systems address two large classes of devices: long-lived and short-lived products. Many devices developed for aerospace and defense applications require test systems that are easy to maintain and update far into the future. In contrast, rapidly evolving commercial wireless products require test systems that can be developed rapidly and within budget— and be easily reused as the products evolve. The ability to meet the needs of either long- or short-lived devices improves with LXI, which is designed fulfill the promise of long-lived measurement hardware, I/O and software.

This need for stability is in sharp contrast to the rapid innovation cycles in today's computer buses. For example, in just a few years instruments based on computer buses have had to change from ISA to EISA to PCI and now to PCI Express (a serial bus not compatible with previous parallel implementations).

In comparison, Ethernet is an extremely stable standard. Like GPIB, it's more than 30 years old— and Ethernet is clearly here to stay. With its stability and other virtues, Ethernet has been adopted in many industries, including corporate communications, consumer electronics, industrial automation and now test equipment.

Ethernet is also a living, evolving standard. It has accommodated the addition of higher-layer protocols as well as enhancements such as Gigabit Ethernet at the physical layer and IPv6 at the network layer. Amazingly, these enhancements have retained backward compatibility, protecting investments in previous versions of the standard.

Reason 7: Cost

Unlike other architectures, LXI isn't an "all or nothing" proposition. You can manage the cost of transition by using devices such as the Agilent E5810A LAN/GPIB gateway to create hybrid systems that include existing GPIB-only equipment alongside LXI-based instrumentation.

When you're ready for an all-LXI test system, it is likely to be less expensive than a system based solely on GPIB, VXI or PXI. This is especially true when compared to VXI and PXI because LXI doesn't require costly cardcages, Slot-0 controllers or proprietary interfaces and cables.

The LAN interface required for LXI is a standard, no-cost feature of most PCs. Also, LAN infrastructure such as hubs, switches and routers is either already available or can be purchased at very moderate cost. For example, Fast Ethernet routers are available for less than US$75 at consumer electronics stores.

In addition to these initial savings, LXI can help reduce support and maintenance cost through its enhanced ease-of-use, flexibility and stability.

Bridging a common gap

Another big advantage with regard to system cost is less obvious. There has always been a gap between R&D applications that rely on benchtop instruments and automated applications that utilize VXI or PXI. LXI can bridge the gap because it accommodates both interactive benchtop instruments and high-performance faceless instruments. The ability to use the same architecture for both types of systems makes it easier to reuse existing software and other solution elements, resulting in lower cost and faster implementation.

Leveraging development effort

In the long term, the base cost of measurement hardware may decline. Although not spelled out in the LXI standard, test-equipment manufacturers will be able to create both benchtop and faceless versions of an instrument, leveraging the same measurement circuitry, I/O hardware and firmware. With greater leverage in product development and the resulting economies of scale, it's realistic to imagine this eventually leading to lower-cost instruments in all three form factors—classic, modular and building-block.

Reason 8: Synchronization through IEEE 1588

The IEEE 1588 standard is another key enabling technology of LXI (see Figure 3). In a nutshell, the purpose of IEEE 1588 is to synchronize the various clocks within a system. The inclusion of this standard in LXI Class B and Class A instruments provides precise timing that enables simultaneous measurements across local and remote devices.

In a typical LXI-enabled distributed application (Reason 5) the system will include intelligent instruments capable of performing measurement tasks on their own, independent of the system controller. To make this approach practical, the instruments will typically include a local clock that enables them to time-stamp measurements and events.

What's especially appealing about IEEE 1588 is that it works across Ethernet—the same Ethernet being used for instrument control. No additional cables are required. Depending on the size of the network and its variation in latency times, it is possible to achieve sub-microsecond synchronization of LXI devices located anywhere on a network—local or remote.
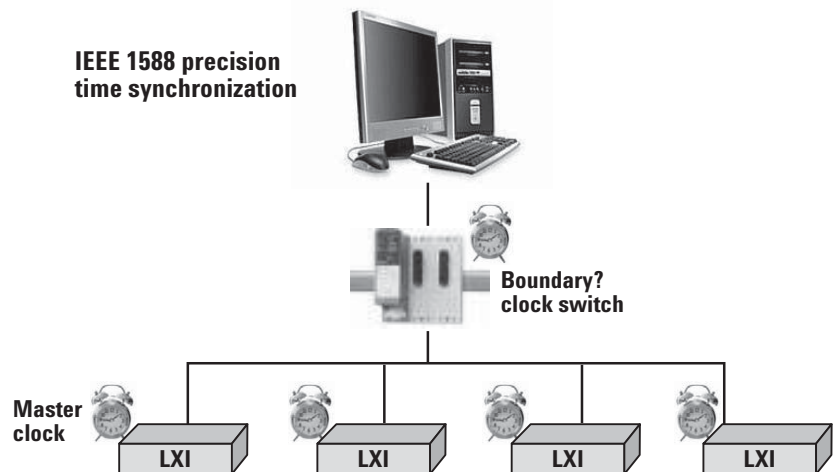

Figure 3. LXI Class A and B devices contain IEEE 1588 protocols and clocks that allow them to synchronize to a master clock on the network with sub-microsecond accuracy.

Reason 9: Rack space

As mentioned in Reason 1, the LXI standard includes an optional mechanical specification. Intended primarily for automated applications, faceless LXI instruments—no display, no buttons—will typically be half-rack in width and 1U to 4U in height. By eliminating the front-panel interface, manufacturers will be able to create smaller versions of oscilloscopes, function generators and DMMs.

The absence of a cardcage also saves rack space. In many cases, cardcages are not fully used, either because the application didn't require it or because the system developer intentionally chose to leave a few slots empty for future enhancement or extension. With LXI, future additions will be easier and the system will consume only the space you need at any given time.

Reason 10: Synthetic instruments

This is an area where LXI really shines by making it possible to implement functional building blocks (e.g., digitizers, downconverters) that can be rearranged on the fly to create multiple instruments. The SI concept reduces hardware redundancy and offers the potential of smaller system footprint, lower hardware costs and simplified long-term support.

Although this approach can be applied to any type of instrument, it is especially well suited to RF instruments. As an example, an RF vector signal analyzer can be broken down into a downconverter, a digitizer and the associated analysis software. Similarly, an RF signal generator can be reduced down to its elementary building blocks. By creating these building blocks as distinct hardware modules and using software to control their arrangement and configuration, it becomes possible to create the functional equivalent of multiple instruments with a handful of modules.

This approach can also reduce the cost of system updates. Because different types of building blocks are based on different technologies, they have different innovation cycles. For example, downconverters contain relatively stable technology but, in contrast, rapid advances in integrated-circuit technology accelerate improvements in digitizer speed and resolution. With SIs, it should be less costly to keep up with the latest advances.

Not surprisingly, LXI is becoming the preferred technology for SI. At the building-block level, communication between these components becomes a critical factor. Rather than relying on custom, instrument-internal communication schemes, Ethernet offers the simultaneous benefits of excellent data rates and the flexibility of peer-to-peer and concurrent communication via TCP/IP.

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Transitioning to the future of test

LXI solves the key problems faced by system developers: it cuts costs, reduces system size, simplifies integration, accelerates throughput and provides more opportunities for reuse of both hardware and software. These benefits make LXI an architecture for both today and the future.

To help you fully realize those benefits, we've adopted LXI as part of the Agilent Open concept. The strength of Agilent Open is in more than just instruments—it's in the way we help you simplify the entire testing process with PC-standard I/O and open software tools (Figure 4). As technology moves forward, our reliance on widely used standards makes it easy to extend system longevity and incorporate new developments such as LXI.

Simplify system connectivity

Choose the I/O connection that fits your test requirements: many Agilent Open instruments are available with GPIB, LAN and USB ports. This flexibility lets you select the interface that works best with your system now—and switch to another one in the future. We also make it easy to incorporate GPIB instruments into LAN- and USB-based systems by offering a variety of interface gateways and converters.

Create versatile measurement solutions

Selecting an Agilent Open instrument for your test system is an easy choice because it's designed for faster throughput as well as easy integration into your test software and your system rack. Whether you choose traditional, modular or building-block instruments, you can connect them quickly and correctly with our IO Libraries Suite. In minutes, its Agilent Connection Expert installs automatically, configures the interfaces, discovers connected instruments from hundreds of manufacturers, and verifies communication.

Achieve efficient development

You shouldn't have to spend time struggling with an unfamiliar programming language just to set up a test. Agilent Open lets you work in the test-software development environment you already know. The key is open software tools such as standard instrument drivers and links to Microsoft Excel or popular programming languages such as Visual Basic, C, LabVIEW, Agilent VEE Pro, Visual Basic.NET, Visual C++, Visual C#, MATLAB® and others. Work where you prefer—and focus on your product, not the code you need to test it.

Through the combined capabilities of Agilent Open and LXI, Agilent can help you and your team open the door to simplified system creation—and new possibilities in testing.
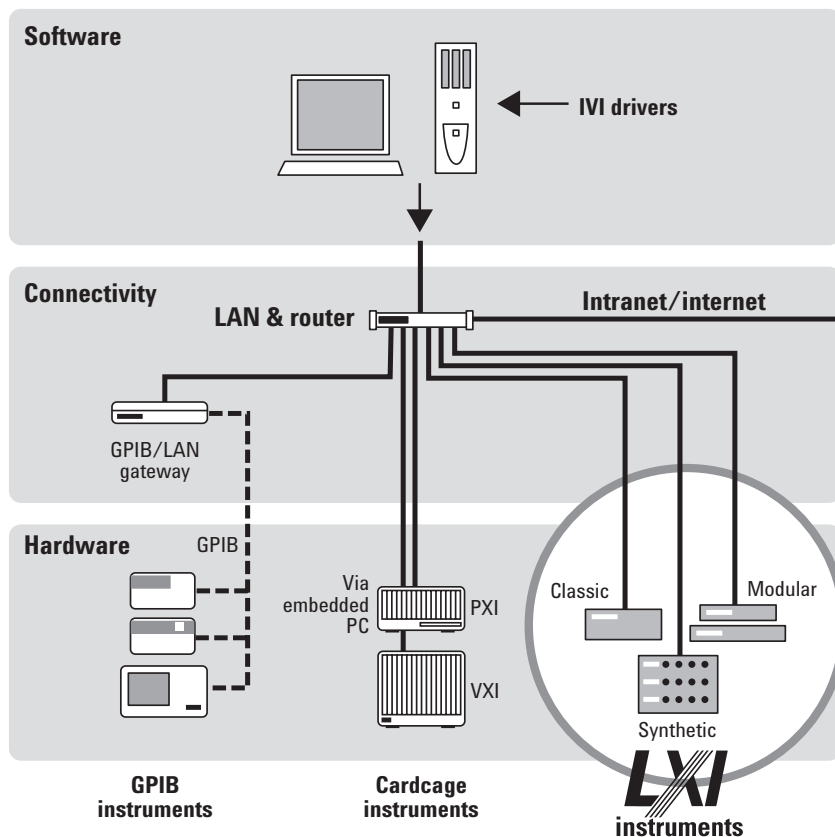

Figure 4. With Agilent Open and LXI, LAN becomes the backbone of test systems that easily incorporate present and future test assets.

Related literature

The 1465 series of application notes provides a wealth of information about the creation of test systems, the successful use of LAN, WLAN and USB in those systems, and the optimization and enhancement of RF/microwave test systems:

- *Introduction to Test System Design,*
  AN 1465-1 (pub no. 5988-9747EN)
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- *Computer I/O Considerations,*
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- *Using LAN in Test Systems: The Basics,*
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- *Using LAN in Test Systems: Applications,*
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- *Using LAN in Test Systems:
  Setting Up System I/O,*
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- *LXI: Going Beyond GPIB, PXI and VXI,*
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