How LXI Extended Functions Expand System Capability

By Tom Sarfi
VTI Instruments

It took years for Ethernet and the Web to transform the way we work. Now it's time for both to transform test systems. That's why more than 52 leading test and measurement companies support LXI (LAN eXtensions for Instrumentation) and offer more than 1,750 different products. LXI makes LAN instruments better, enabling you to create new types of test systems, including local, remote, distributed, and time-aware.

The open LXI standard goes beyond GPIB to provide additional capabilities that help you reduce the time it takes to set up, configure and debug test systems. And LXI lets you leverage the time and effort you've already invested in system software and architecture.

What is LXI?

LXI is an open standard that specifies how to use Ethernet to connect test instruments and build test systems. Developed in 2005 by the LXI Consortium, it enables users to build local and distributed test systems. Often touted as a successor to GPIB, LXI goes beyond GPIB with features such as network based triggering and messaging and extensions for time synchronization and accurate time stamping. Version 1.4 of the LXI Device Specification, released in May 2011 describes both core features, which guarantee instrument interoperability, and extended functions, which support more advanced application requirements.

Using LXI instruments

The LXI Core is a group of features that all LXI instruments must support. They provide a consistent and predictable set of behavior that is critical when developing multi-vendor test systems. The LXI standard ensures that all instruments that conform to the specification are interoperable with one another, thus eliminating costly debugging efforts during system setup.

The core feature set includes:

• **High-speed Ethernet I/O** LXI is based on standard Ethernet technology. This technology supports data rates of 100 Mb/s to 10 Gb/s today, and speeds of 100 Gb/s and 1000 Gb/s are on the horizon. In addition, nearly every computer has an Ethernet port, no matter what operating system it happens to run.

• **Instrument discovery** LXI instruments must support the VXI-11 discovery protocol so that they may be identified in a consistent manner by automated test connection utilities such as NI-

MAX and Agilent Connection Expert. LXI devices also support standard discovery methods common in the commercial world, such as the Bonjour/Rendezvous method and may support custom discovery methods.

• **Web interface** To enable fast setup and verification, LXI instruments must provide a HTML web page (see Figure 1). This interface is available by simply typing an IP address into any World Wide Web Consortium (W3C) compliant browser. The Web interface allows you to immediately verify that your LXI instrument is properly communicating with the host controller as well as monitor and control instrument operation. This type of functionality may or may not be available with LAN-based instruments.

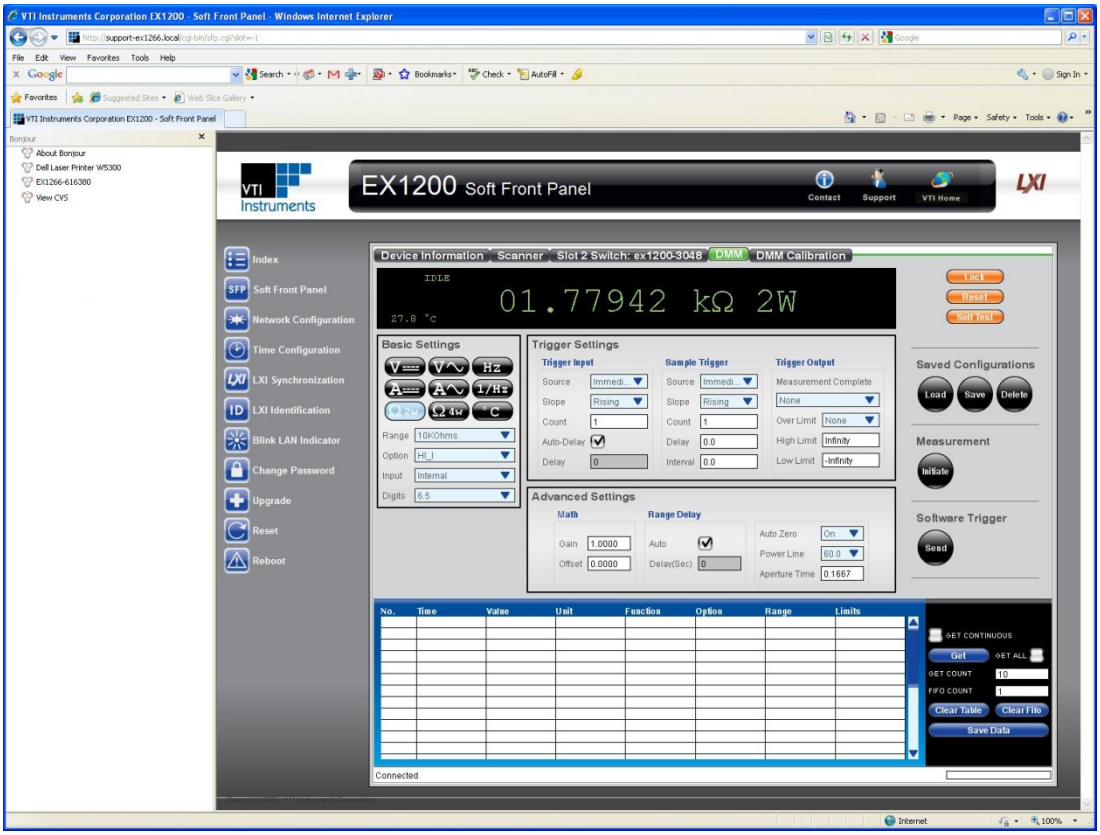

Fig. 1 To conform to the standard, LXI instruments must provide a Web page, like the one shown above, to allow users to monitor and control the instrument.

• **Interchangeable virtual-instrument (IVI) drivers** To make test system programming easier, and ensure that there is a consistent driver architecture in multi-vendor test systems, LXI instruments must be supplied with a standard IVI driver.

Another advantage for LXI instruments is that, by definition, LXI instruments are compatible with GPIB, VXI, and PXI instruments (see Figure 2). This makes it very easy to create hybrid systems. So, if a particular instrumentation function is not available in an LXI instrument, you can use a GPIB, VXI, PXI, or AXIe instrument to make the measurements you need.

LXI's compatibility with GPIB not only means LXI and GPIB instruments can co-exist in a test system, but also that there is a clear migration path for the future. You can use the GPIB instruments that you currently own, but when it's time to replace those instruments because they are approaching the end of their useful life, or you need higher performance, it's very easy to replace them with a compatible LXI instrument.

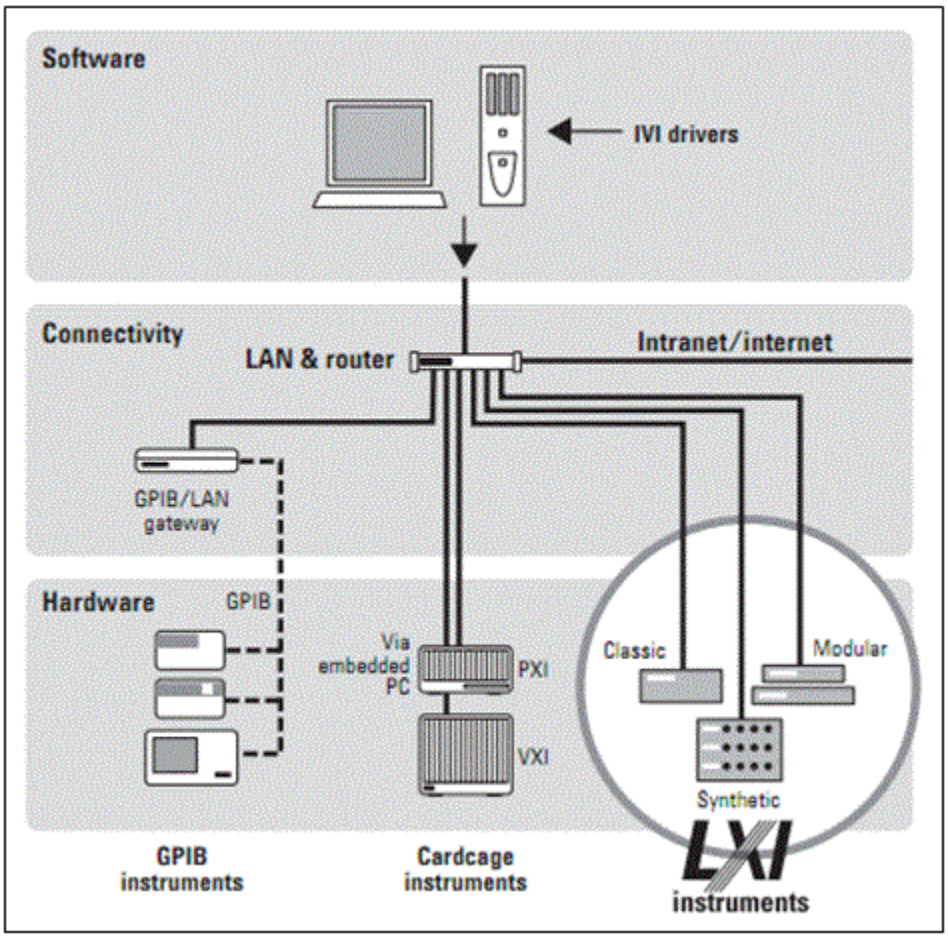

Fig. 2 LXI instruments are compatible with GPIB, VXI, PXI, and AXIe instruments, making it very easy to create hybrid systems.

LXI extended functions

While the LXI core feature set ensures multi-vendor interoperability and provide instruments with more capability than those that simply have a LAN interface, it's the extended functions that really differentiate LXI instruments from LAN instruments.

The new functionality provided by the latest version of the LXI Device Specification allow LXI instruments to be precisely synchronized to a master clock. Data sets collected from multiple LXI instruments can be tightly correlated to a common time base, even if the instruments are distributed across long distances. LXI instruments that incorporate extended functions can also

communicate directly to each other without host controller intervention. These capabilities allow you to:

- Incorporate precision time-stamping of data to discover when operations occurred in the test program

- Optimize system performance by creating built-in handshaking/triggering mechanisms that eliminate wasteful WAIT statements normally used to pace test sequencing.

- Create elegant shutdown sequences in the event of fault without the need to rely on the application program.

The extended function options defined in LXI 1.4 that give users capabilities not found on LAN-based instruments, include:

- **LXI event log** The LXI event log helps you understand what is happening in your instrument or system. This utility records LAN events, allowing you to see what an instrument–or the entire system–is doing. Typical events recorded by the LXI Event Log include enabling the outputs of a power supply, setting a trigger, or taking a measurement as well as when these events occurred. You can also choose to have connection errors added to the event log to make troubleshooting easier.

- **LXI event messaging** LXI event messaging allows devices to signal each other over the Ethernet cable based on events or time without the intervention of a computer. This feature makes the entire system run with extremely low latency in applications that are paced by triggered events. For example, an LXI DMM can trigger an LXI switch to close as soon as it has completed a measurement, and the same switch can send a message to the DMM to initiate a measurement once it has settled.

- **LXI clock synchronization using IEEE1588-2008** LXI clock synchronization using IEEE1588-2008 Precision Time Protocol (PTP) aids creates a mechanism that allows acquired data on several boxes to be tightly time-correlated with one another to reduce errors associated with oscillator drift and jitter. LXI devices that incorporate PTP can be synchronized to a master clock to within tens of nanoseconds with one another.

- **LXI time-stamping** This feature allows you to time-stamp LAN events — such as trigger events, measurements, or state changes such as channel switching –so that you know exactly when they occurred. This feature is useful for both troubleshooting and for data analysis.

- **LXI wired trigger bus (WTB)** The wired trigger bus (see Figure 3) is an optional feature that allows instruments to directly trigger one another in the most demanding triggering applications. The WTB uses a terminated transmission line with eight separate channels to connect LXI instruments. Via the WTB, a system controller can trigger instruments or instruments can trigger one another directly. Using the WTB to trigger your LXI instruments increases the triggering accuracy of your system by orders of

magnitude. With the WTB, you can specify triggering times with an accuracy on the order of nanoseconds. The accuracy of LAN-based triggering, on the other hand, is typically in the millisecond range, depending on how far your packets need to travel.

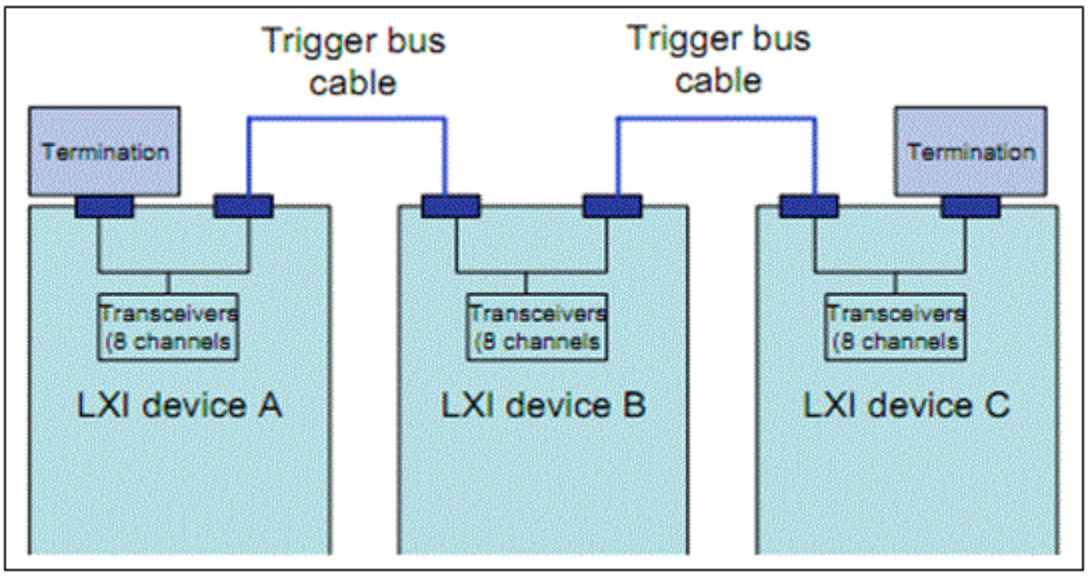

Fig. 3 The LXI Wired Trigger Bus allows instruments to directly trigger one another in applications that demand very precise intermodule communication

LXI distributed applications

LXI's seamless connectivity–both local and global–enables you to develop new distributed applications. This connectivity will improve quality and reduce costs in many cases.

As far as quality is concerned, an LXI distributed system allows the instruments to be closer to the measurements. This means that cable lengths can be shorter and that there will be less loss or variation in excitation voltages. Shorter cable lengths, in conjunction with integrated signal conditioning, also improves your test system's noise immunity.

Shorter cable lengths also help reduce costs. Less wiring in the systems means lower cabling costs and simplifies maintenance.

The ability to connect remotely also helps you save on maintenance costs. Over the Web, you can remotely execute tests, monitor instrument operation, and debug test problems. Instead of sending system experts on costly trips, they can diagnose systems anywhere in the world using a web browser.

Recently, VTI Instruments built a test system for a manufacturer of gas turbine generators (http://www.vtiinstruments.com/CaseStudy/CaseStudy-GasTurbine.html). The system was designed to test generators in the lab, on the production floor, and in the field. The test hardware had to scale from 100 channels for onsite testing to thousands of channels for R&D testing.

The system uses VTI EX1048A Precision Thermocouple Instruments to measure temperatures and EX1000A Precision Voltage Instruments to make measurements from pressure transducers and load cells. The EX1048A and EX1000A-TC devices are both LXI-compliant devices. Not only that they support the LXI extended functions that enable the synchronization of multiple, distributed devices over a single Ethernet cable through the IEEE 1588 Precision Time Protocol. The manufacturer uses this capabilty to synchronize measurements, and this allows them to troubleshoot any out-of-tolerance condition or test failure.

The LXI platform also allows their engineers to remotely monitor installation tests no matter where the tests are being run. This saves both time and money since they can resolve problems quickly without having to send expert personnel to remote locations.

LXI reliability

When you put it all together, you can have confidence in LXI because it is an open, industry standard built on other standards, all of which help you develop reliable, high-performance test systems. On the ground floor, are the physical standards for power, cooling, front panel indicators, and the reset button. Ethernet standards provide a solid network foundation. The IVI standards make test programming easier and make LXI instruments compatible with other test systems. Web standards make interfacing with LXI instruments a snap.

On top of all that, LXI devices require conformance testing to assure performance. LAN-based instruments do not require this testing. The LXI Consortium has third party test companies in the US, Europe, and China. This gives users the confidence that instrumentation from different manufacturers will deliver compatible functionality, which is a key performance benefit of LXI.