Enhancing
Automotive Electronic Test
with LXI

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The automotive industry's highly competitive nature puts intense pressure on electronic manufacturers to boost quality while lowering costs. Activities such as electronic functional test are often viewed as necessary evils that must provide a high return on investment.

Figure 1. Agilent's LXI-compatible 34980A LXI multi-function switch/measure unit allows for insertion and removal of plug-in cards while power is on.

Enter LAN eXtensions for Instrumentation (LXI), an architecture for next-generation test systems based on proven, widely used standards such as Ethernet. Combined with the time-tested principles of providing just enough cooling, power, shielding and physical size to provide superb measurements in modular and traditional form factors, LXI's appeal is bolstered by its availability in bench-top instruments, providing excellent performance at competitive prices.

System designers who test automotive electronics can use LXI to maximize performance, minimize cost and plan for the future. There are at least nine good reasons to consider LXI for present and future test systems, as described in the April 2006 edition of *LXI ConneXion* magazine[1]:

1. Ease of use
2. Performance
3. Cost
4. Scalability
5. Longevity
6. Flexibility
7. Rack space
8. Distributed systems
9. IEEE-1588 synchronization

1. Ease of use

With the year-to-year changes in new car models, automotive electronics manufacturers must bring new products to market quickly. Rapid test system creation depends on getting instruments connected and systems running as soon as possible, which not only saves time but also enables manufacturers to focus on verifying the functionality of a module and its subassemblies.

Many of these systems are created with VXI- or PXI-based hardware and controlled with either an embedded PC or standalone PC connected through an interface card and cable. LXI solves four key problems developers would typically face under these methods:

- **Interface:** Rather than an MXI or GPIB interface, LXI uses Ethernet, eliminating the need to install an additional interface card in the PC. In addition, there are no proprietary cables or software.

- **PC configuration:** Because a PXI cardcage is an extension of the PC backplane, the whole system must be rebooted every time a card is inserted or removed. With LXI, PCs do not require rebooting when connecting or disconnecting instruments. What's more, some modular LXI instruments allow for "hot-docking" of cards while the power is on (Figure 1).

- **Drivers:** When a PXI system reboots, the PC uses an instrument discovery process to identify newly connected devices, which usually requires operators to download and install device drivers. The LXI standard specifies the use of IVI-COM drivers, making it easier to work in a variety of development environments. And some LXI instruments can be programmed directly through Standard Commands for Programmable Instruments (SCPI) when greater functionality or performance is required.

- **User interface:** With no front panel interface, using PC-based system software to diagnose problems in PXI and VXI devices can be difficult. With benchtop LXI instruments, the front panel interface makes it easy for developers to experiment with an instrument. While most modular LXI instruments lack a front panel, their built-in Web interface makes it possible to learn the capabilities by simply opening a Web browser on the connected PC. The browser function also makes it easier to see what's happening with the equipment, simplifying system support and ensuring greater uptime.

2. Performance

Automotive electronics testing includes everything from complex power train control modules requiring hundreds of tests, to simple airbag squib modules, to telematic/infotainment modules that may involve time-consuming transfers of huge data files. These tests often challenge GPIB's maximum data rate of roughly 1 MB/s. With LAN, I/O transfer speed is becoming a non-issue with 1-Gbit/s connections becoming commonplace and 10-Gbit/s on the way.[2]

I/O performance should not be an issue for LXI devices in typical automotive applications that require both transactional programming and transfers of large data blocks such as waveforms captured by digitizers. In transactional programming, there is a well-understood issue around LAN latency. Instrumentation vendors are reducing the number of required communication cycles by preloading instructions to LXI devices.

3. Cost

Minimizing the overall cost of test requires fast, reliable testing at as low a price as possible. Some trade publications have suggested that functional test adds no value: At this late stage, most manufacturers have inspected incoming parts, performed X-ray inspection and completed in-circuit test. While these steps do improve product quality, they do not eliminate the need for functional test because they cannot detect faults due to post-assembly product failures, design errors or inaccessible nodes.

Automakers' seemingly conflicting requirements compound matters. Instruments that deliver the necessary capabilities and performance at an attractive price can solve these issues, as can careful consideration of both initial hardware cost and recurring costs such as spares, warranties, local versus return-to-factory repair options and availability of rental equipment. In many cases, an instrument-by-instrument price comparison will show up to 40 percent reductions in the cost of LXI versus PXI hardware.[3]

It is also worthwhile to account for the learning-curve costs of cardcage instruments versus LXI. Cardcage instruments require the use of different software drivers for each development environment such as LabVIEW, Visual Basic and C++. LXI instruments generally offer a choice, enabling use of either drivers or SCPI.

4. Scalability

Figure 2 shows a typical automotive electronic functional test system built with LXI devices: expandable reed relay matrix, many armature-relay load switches, many channels of arbitrary waveform output and many channels of D/A conversion. In a cardcage-based system, these devices can quickly fill every slot, and the addition of just one more device requires another cardcage and computer interface. For systems requiring just a few cards, the cardcage adds cost and consumes space, though the empty slots allow for future expansion. LXI instruments provide the desired functionality, making it easy to upgrade functionality without adding a cardcage or computer interface. At most, the system may require the addition of a low-cost LAN switch to provide ports for added LXI devices.

Figure 2. In an automotive test system, LXI components enable greater scalability and flexibility to meet present and future needs.

5. Longevity

Figure 3 provides a comparison of various interfaces over the past 30-plus years. Most noteworthy is the continuous improvement in LAN performance while maintaining backward compatibility, suggesting that it will continue as a dominant force in the computer industry for a long time to come.

Extensions designed into the LXI Standard ensure that it will meet the foreseeable needs of the test and measurement industry, a critical requirement of the automotive electronics industry that supports an active aftermarket and long product lifetimes.

6. Flexibility

Cardcage-based solutions limit the optimal instrumentation placement in a test rack. For example, system creators will find it useful to put switching in one low-cost subsystem and stimulus/measurement instruments in another, simplifying service and avoiding use of high-cost, high-performance backplanes to control slow relays (often the case in PXI or VXI cardcages).

LXI instrumentation enables a better approach: A modular switch/measure unit equipped with an internal digital multimeter (DMM) and a selection of switching cards offers a low-cost method of creating a dedicated switching subsystem. The use of LAN also makes it possible to place the LXI-based subsystem farther from the host PC and closer to the unit under test.

Few cardcage-based power supplies meet the current requirements of many automotive electronic modules and require external power supplies based on different architectures. Agilent has updated existing designs to be LXI compliant, housing them in compact, rack-friendly enclosures. Examples include the Agilent N5700 series of high-power supplies and the Agilent N6700 series of modular supplies (Figure 4).

Figure 4. Some LXI-compliant power supplies have size, power and functionality advantages over GPIB and PXI alternatives.
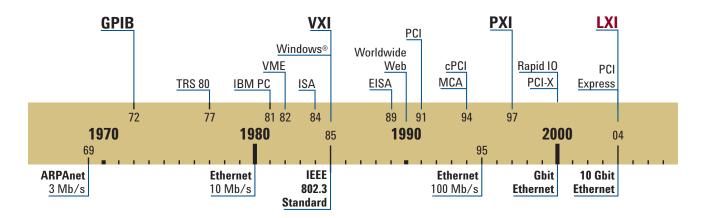

Figure 3. LAN has evolved — and maintained backward compatibility — while other interfaces have come and gone.

7. Rack space

An LXI-based functional test system could be assembled in a rack as small as 750 mm tall (Figure 5). This space efficiency is due in part to LXI-based devices such as an eight-slot switch/measure unit with a built-in DMM (second position in rack) and a 1U modular power system (lowest position in rack).

To achieve maximum density, system developers often use cardcage-based instrumentation. With VXI, a C-size cardcage can hold up to 12 high-performance

instruments in about 6U, but this is often an expensive solution. PXI also provides high density, but its compact 4U size has four key shortcomings that are addressed by LXI:

Card size: Due to PXI card size, it may be necessary to use more than one slot to achieve the needed functionality. LXI instruments, on the other hand, can be created in a variety of sizes to ensure they fulfill their intended use.

Shielding: PXI cards are susceptible to interference. For example, a Signal Conditioning eXtensions for Instrumentation (SCXI) power supply that emits high levels of magnetic interference can lower the performance of an adjacent PXI DMM, potentially lowering DMM performance by a full digit of resolution. LXI devices are inherently shielded because they are fully self-contained.

Cooling and power: Cardcages must provide sufficient cooling and power supply capacity to handle a maximum number of instruments or relays at one time. In demanding systems, it may be necessary to upgrade to one or more higher-cost mainframes capable of providing the required cooling and power. Automotive electronics applications also often require instrumentation output voltages that exceed the voltage capability of many PXI mainframes. LXI instruments are generally designed to provide the required power, voltage and cooling for their target application.

8. Distributed systems

Automotive production test systems typically co-locate all instruments. However, there is an inherent benefit to applications such as durability test systems, R&D test systems and production validation systems when operators can place LXI instruments where the measurement needs to be made.

Production test systems also can benefit from a remote test-head. With off-the-shelf LXI switch modules, it is possible to create a test fixture that automatically adapts to any engine control module coming down the line, for example.

The ability to put the stimulus and measurement instruments where they are needed — with minimal or no cabling back to the core of the system — is a feature unique to LXI. Modules such as the Agilent L4400A series are designed for this type of remote or distributed application (Figure 6).

Another factor that favors LXI is remote debugging and trouble-shooting. Service technicians with remote access privileges can diagnose a test system from practically anywhere using a Web browser. If a LAN-connected webcam is added to the system, the remote technician can even see what is happening as they troubleshoot.

9. IEEE-1588 synchronization

In high-volume production lines, the ability to shave even one second of test time per module may be worth thousands of dollars. In such cases, any change to hardware or software that causes an increase in test execution time is unacceptable.

LXI addresses test time through extensive triggering capabilities, beginning with a standardized trigger bus in Class A LXI instruments. LXI also provides a new way to improve test execution time: self-triggered measurements based on a precise real-time clock are synchronized from instrument to instrument. With this capability, measurements can be performed without intervention from the host computer, minimizing or even eliminating trigger wiring in a test system and reducing I/O bottlenecks.[4]

Conclusion

LXI is built for the long haul and is well-suited to automotive electronic test. Its main benefits are in cost, scalability and ease-of-use, but LXI also offers advantages in performance, longevity, flexibility, synchronization and rack space. More information is available online at www.lxistandard.org and www.agilent.com/find/lxi.

References

1. *LXI ConneXion*, April 2006, Stefan Kopp; available from www.lxiconnexion.com

2. LAN latency issue, *The Application of IEEE 1588 to Test and Measurement Systems* by John C. Eidson; available from www.lxistandard.org

3. Agilent application note *A Comparison Between PXI and the Agilent 34980A for Switch/Measure Applications* shows a 40 percent savings; publication number 5989-5852EN available from www.agilent.com

4. Online article, "Making High Speed Measurements Through Triggering," available from www.agilent.com

Figure 6. LXI-based switching modules enable the creation of powerful remote test systems.

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LXI

www.lxistandard.org
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