Enhance car electronic test with LXI

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The competitive nature of the automotive industry generates constant pressure to boost product quality while driving down costs. Hence, demanding but useful activities such as electronic functional test are often tagged as "necessary evils" that must guarantee a high return on investment. System designers responsible for testing automotive electronics then require architectures that can maximize performance, minimize cost and plan for the future. An example of these test systems is the LAN eXtensions for Instrumentation (LXI) solution.

Performance, costs

Yearly changes in car models require manufacturers of automotive electronics to bring new products to market in a very short time. Factors that impede rapid development of test systems or decrease production uptime are not tolerated. Thus, rapid system creation depends on getting instruments connected and systems running as soon as possible. This enables manufacturers to focus on verifying the functionality of a module and its subassemblies.

Most of these systems are created with VXI- or PXI-based hardware. As they are controlled with either an embedded PC or a standalone PC connected through an interface card and cable, developers face four key problems that LXI addresses:

- Interface—Rather than an MXI or GPIB interface, LXI uses the Ethernet. Thus, it does not require the installation of an additional interface card in the PC, proprietary cables and software. The solution can run systems in minutes instead of hours.
- 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. This is not an issue with LXI. Its LAN connection makes it unnecessary to reboot the PC when connecting or disconnecting instruments. Moreover, several modular LXI instruments allow for "hot-docking" or the insertion and removal of cards while power is on.
- Drivers—When a PXI system reboots, the PC uses an instrument discovery process to identify newly connected devices—and this requires downloading and installation of device drivers, which can take up time. The LXI Standard specifies the use of IVI-COM drivers, which make it easier to work in different development environments. However, some LXI instruments can be programmed directly through Standard Commands for Programmable Instruments (SCPI) when greater functionality or performance is required. SCPI can be used with any computer language through simple VISA function calls.
- User interface—With no front-panel interface, it can be difficult to use the PC-based software to diagnose problems in PXI and VXI devices. Using benchtop LXI instruments, the front-panel interface makes it easy to experiment with an instrument and learn how it works. Most modular LXI instruments lack a front panel and instead have a built-in Web interface that allows engineers to learn device capabilities by opening a Web browser on the connected PC. The browser function also enables engineers to view the equipment's development from anywhere in the world, simplifying system support and ensuring greater system uptime.

Testing of automotive electronics includes complex powertrain control modules that require thousands of tests and simple airbag modules that may require large data transfer. These tests often challenge the speed of GPIB, which has up to 1MBps data rate. Using LAN, I/O transfer speed is now a non-issue, with

Figure 2: The 34980A LXI multifunction switch/measure unit is a low-cost, eight-slot mainframe with optional built-in DMM, making it a cost-effective choice as a switching subsystem.

Figure 1: LXI instruments include front panels, enabling engineers to easily learn and debug their operation without connecting to a computer.

Figure 3: In an automotive test system, LXI components enable greater scalability and flexibility to meet test requirements.

1Gbps connections becoming commonplace and 10Gbit versions on the way.

I/O performance is not an issue for LXI devices in automotive applications that require both transactional programming and transfer of large data blocks. The speed of LAN allows the transfer of large data blocks such as a waveform captured by a digitizer. In transactional programming, LAN faces the issue of latency, which is also an issue for storage networks. To reduce the number of required communication cycles, instructions are preloaded to LXI devices.

Minimizing the overall cost of test requires fast, reliable testing at the lowest possible price. There were suggestions that functional test adds no value—at that late stage of the manufacturing process, most manufacturers have inspected incoming parts, performed X-ray inspection and completed in-circuit test. These steps do improve product quality, but do not eliminate the need for functional test because they cannot detect faults due to infant mortality, design errors and inaccessible nodes.

All this is compounded by conflicting requirements of automakers as they can impose penalties for both late shipments and high defect rates. To solve this, instruments must deliver optimum capabilities and performance for the money (**Figure 2**). It also requires 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.

It is also worthwhile to account for the learning-curve costs of cardcage instruments vs. LXI. Cardcage instruments require different software drivers for each development environment—LabVIEW, Visual Basic, C++ and so on. LXI instruments generally offer a choice, enabling use of either drivers or SCPI. For developers familiar with SCPI, the instrument learning curve is typically short. The IntelliSense help functions and online documentation of the .NET environment help simplify programming with drivers.

Figure 4: Some LXI power supplies have size and functionality advantages over GPIB and PXI models.

Additional features

A typical automotive electronic functional test system built with LXI devices contains expandable reed relay matrix, armature-relay load switches, channels of arbitrary waveform output and channels of D/A conversion (**Figure 3**).

In a cardcage-based system, these devices can quickly fill every slot and then additional devices will require another cardcage and computer interface. For simple systems that need just a few cards, the cardcage adds cost and consumes space, though the empty slots allow for future expansion. LXI instruments provide the exact functionality needed and makes it easy to add devices without requiring another cardcage or computer interface. At most, the system may require the addition of a low-cost LAN switch to provide more ports for added LXI devices.

There has been continuous improvement in LAN performance over the years while maintaining backward-compatibility. The widespread adoption of LAN suggests that it will continue to be a dominant force in the computer industry for a long time. The extensions designed into the LXI Standard ensure that it will meet industry needs for test and measurement for a long time. The need for longevity is important for the automotive electronics industry, which supports an active aftermarket and long product lifetimes.

In terms of flexibility, cardcage-based solutions limit the optimal placement of instrumentation in a test rack. For example, it is useful to put switching in one low-cost subsystem and stimulus/measurement instruments in another. This simplifies service and also avoids the inefficient use of costly backplanes to control slow relays.

Figure 5: With LXI, a functional test system can fit into a rack that is just 400mm tall.

LXI instrumentation also enables a new approach for flexibility. For example, an LXI-based device that has internal DMM and selection of switching cards can offer a low-cost, dedicated method to create a switching subsystem. This feature also enables the LXI-based instrumentation subsystem to be placed elsewhere.

Functionality can also be an issue. Few cardcage-based power supplies meet the current requirements of automotive electronic modules. This requires the use of external power supplies based on different architectures such as those that are LXI-compliant.

Modern designs have additional improvements, such as fast up/down programming, power waveform creation and monitoring, and compact enclosures. Examples of this are shown in **Figure 4**.

In automotive applications, an LXI-based functional test system can be assembled in a 400mm tall rack (**Figure 5**). Some LXI-based devices can partly contribute to this space efficiency.

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 a high-cost solution. PXI also provides high density, but its compact 4U size has four key shortcomings:

- Card size—The size of PXI cards sometimes requires the use of more than one slot to achieve the needed functionality. LXI instruments can be created in various sizes to fit their intended use.
- Shielding—PXI cards suffer from different interference issues. For example, an SCXI power supply that emits high magnetic interference can lower the performance of an adjacent PXI DMM, potentially lowering DMM performance by a full digit of resolution. VXI avoids such problems because it requires that all cards have shielded enclosures. Likewise, 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 several higher-cost mainframes that can provide the required cooling and power. Furthermore, applications in automotive electronics often require instrumentation output voltages that exceed the voltage capability of many PXI mainframes. Most LXI instruments can provide the required power, voltage and cooling for their target application.

Figure 6: The Agilent L4400A series of LXI switching modules enables the creation of powerful remote test systems.

Unique capabilities

Automotive production test systems typically co-locate all of their instruments. However, durability test systems, R&D test systems and production validation systems can benefit from placing LXI instruments where the measurement must be made.

Production test systems can also 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, whatever the pinout. This could be mounted inside an enclosure and attached inside a robotic final test cage.

LXI modules have the ability to put the stimulus and measurement instruments where they are needed—with minimal or even no cabling back to the core of the system. Modules such as the Agilent L4400A series—1U high and no front panel—are designed for this type of remote or distributed application (**Figure 6**).

Another factor that favors LXI is remote debugging and troubleshooting. Service technicians with remote access privileges can diagnose a test system from anywhere in the world simply by using a Web browser. If a LAN-connected Webcam is added to the system, the remote technician can see what's happening as they troubleshoot the system from afar.

Furthermore, in high-volume production lines, the ability to shave off 1s of test time per module can be worth thousands of dollars. In such case, any change to hardware or software that causes an increase in test execution time is totally unacceptable.

LXI addresses this through extensive triggering capabilities. It starts with a standardized trigger bus in Class A LXI instruments. LXI goes farther, providing 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 based on IEEE-1588, complicated and time-consuming measurements are performed without intervention from the host computer. This can minimize or eliminate trigger wiring a test system and reduce I/O bottlenecks. This new capability is yet to be available on all LXI devices.

Figure 7: The Agilent N8201A 26.5 GHz performance downconverter is one example of an LXI-based synthetic instrument module.

As cars become rolling hubs of Internet, cellphone and GPS connectivity, they use multiple types of wireless communication. Consequently, test requirements in the automotive industry are beginning to merge with those of the telecom and aerospace/defense industries—and more RF test sets will likely make their way into automotive electronic test systems in the future.

For example, the U.S. aerospace/defense industry is demanding discrete instrumentation building blocks—RF amplifiers, up- and downconverters, digitizers—that can be easily arranged and rearranged on the fly to provide the functionality of oscilloscopes, network analyzers and spectrum analyzers. An example of this device is shown in **Figure 7**.