ENHANCING TODAY'S TEST SYSTEM FUNCTIONALITY THROUGH EMERGING TECHNOLOGY

Jon Semancik
VXI Technology, Inc.
2031 Main Street
Irvine, CA 92614
949-955-1894
jons@vxitech.com

Abstract - The VXI-bus is the platform of choice for many military and commercial test systems primarily because it offers the user a solution that is open-platform based, computer and operating system independent, and highly modular. The densities and performance offered are unmatched by any other platform, and multiple vendor support has ensured long life-cycle management. The emergence of the LAN Extension for Instrumentation (LXI) Standard, leveraging all the advantages of Ethernet while adding several critical components necessary for true test and measurement compatibility, has offered a glimpse into the future of test system interfaces. However, what options are available to the user to ensure existing system sustainability, and can the LXI Standard truly solve all test applications currently addressed by other open-architecture platforms?

INTRODUCTION

Historical data indicates that test engineers are accustomed to integrating hardware with different physical interfaces. For example, power supplies may only provide an RS232 interface, a high frequency spectrum analyzer might utilize GPIB, and the switching and general purpose source and measurement instrumentation are housed in a VXI chassis with a MXI-2 parallel interface. This combination of interfaces is required because the test engineer must select the best solution to address his requirements; however, the approach inherently drives the cost of the system as well as complexity.

One of the fundamental advantages of LXI-based instrumentation is that all devices can reside on a common inexpensive interface that is extremely stable and that has been evolving for the past forty years. The interface is platform and operating system independent, and is integrated into nearly every computer available on the market. Even with these advantages one must evaluate the various use case scenarios in order to determine if LXI can address all applications and if not, what must be done to ensure that engineers are still not faced with the dilemma of mixing and matching interfaces.

A common use case likely to arise involves the need to tightly integrate a sequence of control signals in a source, measure, and switch scenario where deterministic, repeatable operation is ensured. Often this type of application also involves a large number of test points, and may also include the need to switch high voltage and current levels. The VXI platform is an ideal solution for this type of application, but standard interfaces available today will still result in the creation of an interface-restricted subsystem. The key to resolving this issue is a bridge between the VXI chassis and the LXI network community.

The concept of a bridge device immediately expands the utility of the LXI beyond that of just another new emerging standard. This implementation will enable a wide range of current and future test systems to leverage the advantages of LXI, but there are still fundamental issues that must be addressed before wide adoption is possible. Several issues of critical importance include:

- Bridge Device Functionality
- Hardware Triggering
- Synchronization
- Software Interface
- Test Sequencing

BRIDGE DEVICE FUNCTIONALITY

One key purpose of a bridge device is to provide the communications link between the platform of interest and the LXI network. Essential characteristics of this device include compliance to all LXI Class C requirements which define the network and LAN functionality; device discovery, IP address allocation, and behavior in the event of network conflicts are just some of the requirements. However, how will a platform that incorporates a host interface to control a variety of independent, highly synchronized devices, such as VXI or PXI instruments and switches, function within this environment?

An LXI-VXI slot-zero control bridge, for example, must perform all of the functions expected of any VXI controller, in addition to providing the LXI interface functionality for the external network. This includes providing a communications path for the host computer, facilitating instrument and switch card discovery (within the chassis), memory allocation, trigger distribution and generation, and error reporting. Individual instruments within the chassis will continue to be identified utilizing the familiar VISA resource name scheme:

TCPIP[board]::host address[::LAN device name][::INSTR]
TCPIP::10.1.2.119::INSTR

Each of the instruments or switch cards within the chassis will function independent of the LXI interface, and retain all of the exceptional timing and synchronization characteristics that have driven wide industry acceptance of platforms such as VXI. Internal backplane functionality is unaffected by the LXI bridge, and performance characteristics such as data transfer rates, device triggering, high-speed local bus, and power supply capabilities are retained. Furthermore, other devices (LXI, LXI-VXI Controllers, or non-LXI) can easily interface with bridge devices, thanks to the functionality described in the Hardware Trigger Section.

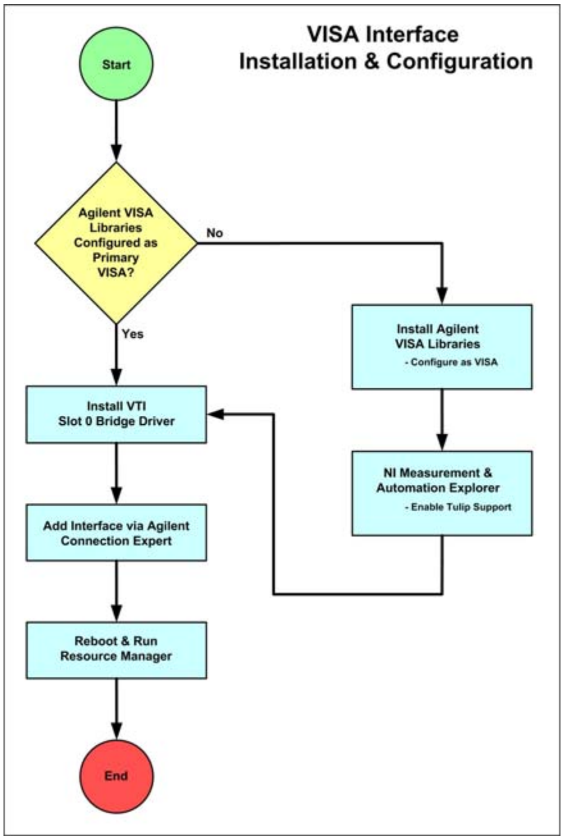
SOFTWARE INTERFACE

Another key attribute of any bridge device is the ability to seamlessly transition between interfaces.

A typical test system will have significant man-hours invested in software and test program development; therefore, the ability to minimize the impact on currently fielded software is essential. Updating a traditional VXI-based system should be as simple as removing the existing slot 0 interface, updating the instrument drivers, and installing the new LXI-VXI slot-zero control bridge.

The transition to a LXI-VXI bridge will typically involve no user code modifications. This is primarily because of the functionality provided by the VISA I/O libraries, which are designed with utilities for configuring, programming, and troubleshooting instrumentation systems. There are essentially two widely accepted VISA implementations in the market, Agilent VISA and National Instruments (NI) VISA, and the upgrade process varies slightly depending on the architecture that the manufacturer has adopted. The process defined in Figure 1 assumes that the LXI-VXI slot-zero control bridge implements the Agilent VISA interface, and illustrates the steps required for upgrading the bridge in both a native Agilent and native NI environment.

Figure 1



One step of particular interest involves adding the interface using Agilent's Connection Expert. This step essentially maps the LXI compliant resource string to the VXI resource string that would be in use in the existing system (See Figure 2). Once this has been completed all existing code will execute without any additional modifications.

Figure 2

HARDWARE TRIGGERING

The most accurate synchronization mechanism between multiple devices, regardless of the platform, involves the implementation of a hardware trigger interface. Most functional test applications follow a relatively straight forward approach that involves defining a signal path, applying a stimulus to the unit under test (UUT) and then measuring the results. The key to generating accurate results is often linked to the timing associated with the test sequence, and this is where the trigger interface comes into play. As a result of this requirement a high-performance trigger interface, the LXI TriggerBus has been implemented in LXI Class A devices and provides the link between all devices in the test system for both triggering and clock signal distribution.

Deterministic trigger generation and propagation between multiple devices is accomplished with an eight-channel, multipoint, low-voltage, differential signal (LVDS) interface. This architecture permits individual lines to be configured as a source and/or receiver and supports external, time-based or software-generated triggering as well as clock distribution. Common topologies are supported including star, daisy-chain, and hybrid configurations, providing the flexibility to distribute the trigger lines as dictated by the application requirements. Additional flexibility is realized with the addition of a star hub; this device permits very tight trigger tolerances to be maintained throughout a large distribution network (See Figures 3 and 4).

Figure 3

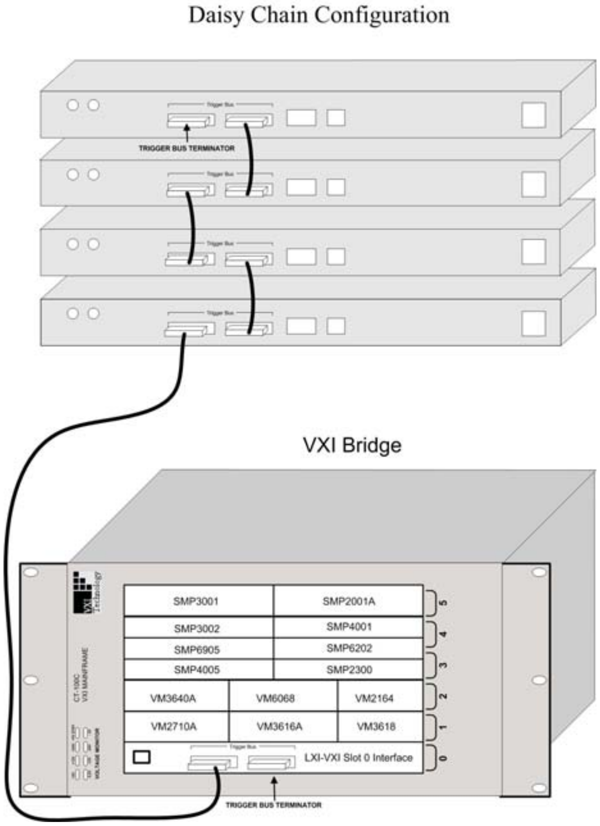
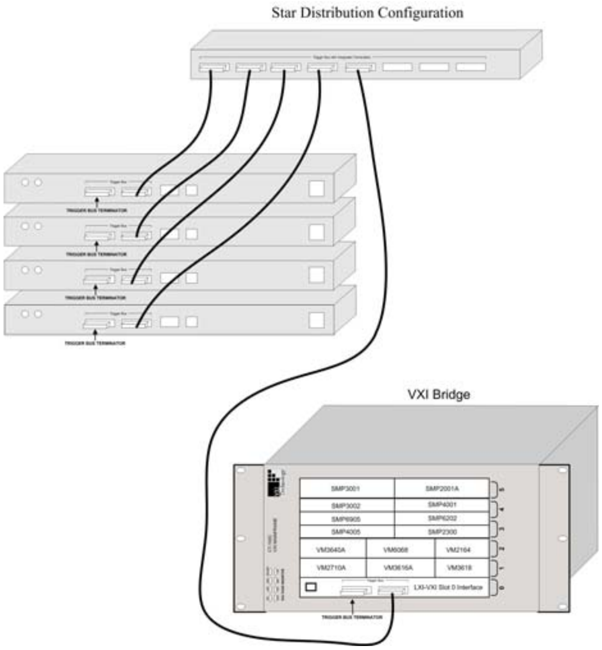
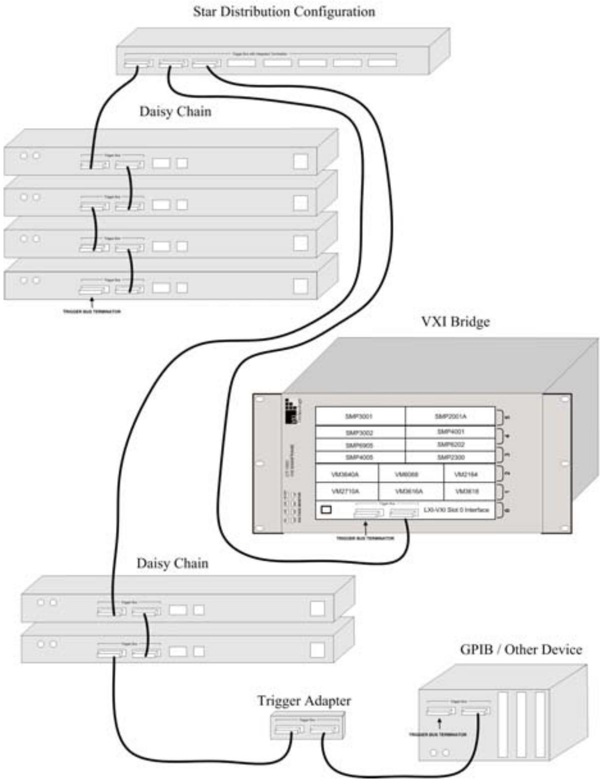


Figure 4



Additionally, the TriggerBus is automatically extended into the VXI platform with a LXI-VXI slot-zero control bridge, providing a mechanism to link a VXI chassis and all other LXI hardware. The LXI-VXI slot-zero control bridge will provide a direct extension of the eight VXI trigger lines to any external device, providing the ability to individually control specific instruments and switch devices with the VXI chassis. This type of flexibility will provide the user the ability to integrate stand-alone instruments, such as spectrum analyzers and power sources, into a homogeneous test environment leveraging the strengths of each subsystem. Required functionality, such as a high-density, high-performance switch subsystem, uniquely inherent in VXI-based devices, can function transparently with LXI-based synthetic instruments without additional integration activities (See Figure 5).

Figure 5



LAN SYNCHRONIZATION

LAN synchronization, incorporating the IEEE-1588 Precision Time Protocol (PTP), highlights another fundamental advantage of LXI Class B devices. PTP defines a precision clock synchronization protocol for networked measurement and control systems. The protocol is designed to enable the synchronization of systems that include clocks of different precision, resolution and stability. Sub-microsecond accuracy can be achieved with minimal network and local clock computing resources, and with little administrative attention from the user.

There are several ways in which PTP can be implemented ranging from user level software control, to kernel-level driver modifications, to hardware implementations utilizing dedicated FPGA devices. The highest level of precision is obtained when hardware implementations assist in the time stamping of incoming and outgoing network packets or frames; delay fluctuations can be in the nanosecond range with this approach. PTP provides multiple device synchronization while eliminating the need for external cabling between devices. Utilization of this approach is less accurate than hardware triggering; however, Giga-bit Ethernet can provide synchronization times in the hundreds of nanoseconds range.

Synchronization of hybrid test systems, including standalone instruments as well as VXI-based sub-systems, can easily be accomplished with a test approach that utilizes time based execution. The background PTP functionality ensures that each device is synchronized to within a high degree of certainty of one another. Test sequences can then be initiated at specific time slots based upon the relative PTP time. An LXI-VXI slot-zero control bridge can respond to a PTP based event in a number of different ways ranging from initiating a specific control source/measure function on a discrete instrument to generating an entire sub-system test sequence involving multiple source, measure, and switch devices.

TEST SEQUENCING

The application space that a solution addresses will clearly dictate the approach required for control, data transfer, and software and hardware handshaking. Many data acquisition applications only involve gathering large amounts of data and then transferring large quantities of data, typically referred to as block mode transfers. Conversely, many functional test applications require a significant number of single measurement related commands and transfers based upon events that occur during the test process. Again, a common test sequence involves setting the test path through switching, enabling source devices, and then measuring the results.

A certain amount of delay is built into any test sequence involving relays due to settling and debounce times (3-5 milli-second typical) inherent in mechanical devices; however, not all test processes involve a continual step-sequence such as this. A number of signal paths may be defined followed by analog source level changes or digital pattern modifications that involve extremely fast setup times. The hardware TriggerBus interface provides a deterministic control path for updating the state of a device or acquiring a result, and the LXI-VXI Bridge extends this capability to all devices on the backplane without additional hardware.

SUMMARY

A seamless link between existing open-architecture hardware platforms and LXI devices is essential if wide industry acceptance of the interface is to emerge. The adoption of any new standard is typically an incremental process that involves combining various devices in a hybrid configuration that enables the end user to evaluate these technologies prior to wide acceptance. Therefore it is essential that manufacturers provide the mechanism to facilitate this transition.

Furthermore, there will always be applications that demand the performance of open-platform, chassis-based modular systems such as VXI, and providing bridge interfaces completes a logical link into these systems. Engineers seldom appreciate having their design path dictated, and welcome the freedom to choose the solution that best fits the need. Bridge interfaces and transition devices will ensure this freedom of choice and foster the adoption of the LXI Standard in a well thought out, logical manner.