



Open Architecture Design Ideal for Boeing 787 Structural Test

Introduction

Open architecture designs, such as those incorporating the VXIbus, have long been the choice for many military and commercial test systems. This is primarily because they offer the user a solution that is open-hardware and open-software based, computer and operating system independent, and highly modular in nature.

The introduction of the LAN Extensions for Instrumentation (LXI) Standard has added another platform alternative, incorporating all of the open-architecture advantages of Ethernet while adding several critical components necessary for true test and measurement compatibility. LXI offers a glimpse into the future of test system interfaces that is of particular interest to designers who wish to leverage open-platform architectures for distributed measurement applications.

Open Architecture Environment

The advantages of adopting an open architecture test platform span both hardware and software, providing the engineer with a wide range of choices not available to those locked into proprietary designs. An open hardware approach guarantees that a well defined set of signal and interface characteristics have been adopted, and that multiple vendors have joined together to provide support and product development. All of this results in reduced cost, extended test system life cycles, and commercial off the shelf (COTS) product availability.

Open software support also plays an important role in reducing development costs and ensuring life cycle management. Software independence is built upon well defined standards such as those seen in plug&play drivers and IVI, and this is further extended into the application development environment providing the engineer with freedom of choice to select the environment best suited to meet their needs. Properly designed drivers can easily be used in a number of different application programming environments including C/C++, MatLAB, Visual Basic, VEE, and LabVIEW / LabWindows CVI.

Distributed Measurement Approach

Open hardware and software are fundamental requirements for any truly sustainable platform, but system designs utilizing the LXI platform also provide an inherent benefit that is ideal for distributed data acquisition applications. Many current data acquisition implementations involve placing the instrumentation in a control room that may be located hundreds of feet from the article that is being tested. This distance presents numerous challenges to the test engineer including cable cost, maintenance, calibration, noise, and debugging. Fortunately the effects from most of these issues are greatly reduced by placing the instrumentation as near to the test article as possible.

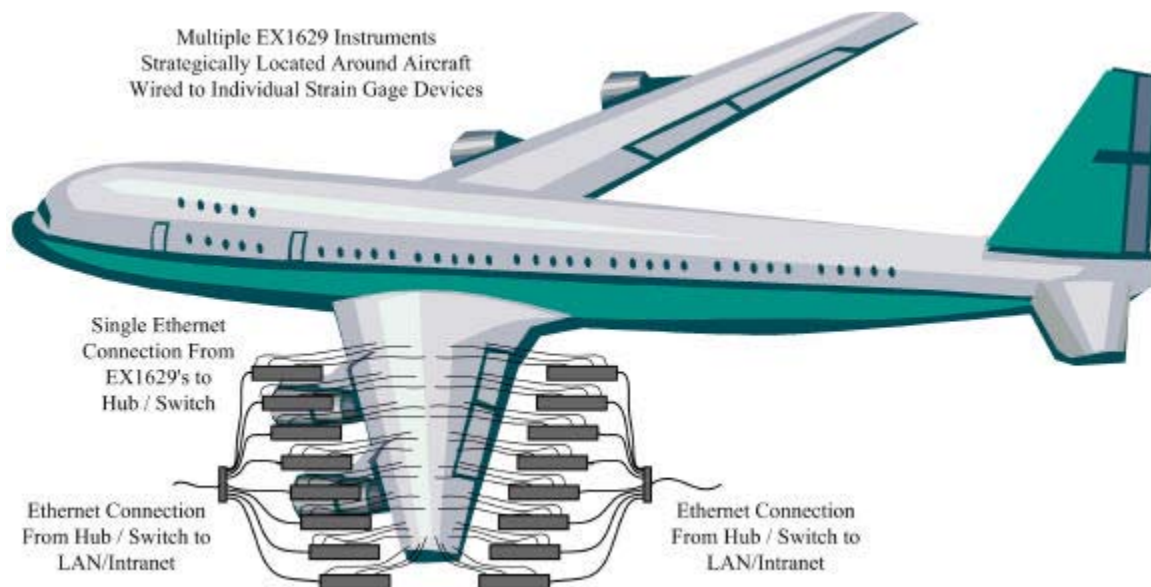


Figure 1.

Aircraft structural test applications illustrate this concept clearly; not only is the test performed some distance from the control room but the sheer size of the test article is an additional challenge. Fatigue testing on an aircraft wing may involve several thousand channels of strain gage transducers that must be located at strategic points on the structure. It is not difficult to imagine the magnitude of the installation and setup task for three thousand channels, especially if 10-wire connections are required. The cost of the cabling and installation will be significant, measurement errors due to cabling must be considered, and long term maintenance and support will also be an issue.

Distributed LXI-based instrumentation, such as VXI Technology's EX1629, 48-channel high-performance remote strain measurement unit can greatly simplify the task. Each EX1629 can be placed near the test structure and connected to the test local area network (LAN) utilizing standard Ethernet cable and networking accessories (See Figure 1). A single Ethernet cable can then be routed to the control room for data collection and control. While this approach simplifies installation and addresses several key areas of concern, a distributed approach must still address synchronization and trigger control issues common to most data acquisition applications.

LAN Synchronization

LAN synchronization, incorporating IEEE-1588 Precision Time Protocol (PTP), provides the ability to synchronize multiple devices utilizing only the LAN Ethernet connection; another fundamental advantage of LXI based devices. PTP defines a precision clock synchronization protocol for networked measurement and control systems which 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 nanosecond range which may be suitable for slower data acquisition rates common with thermocouple measurements.

Hardware Trigger

The most accurate and deterministic synchronization mechanism between multiple devices involves the implementation of a hardware trigger interface. As a result of this requirement, the LXI standard defines a high-performance trigger interface referred to as TriggerBus. TriggerBus can provide 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 Figure2.

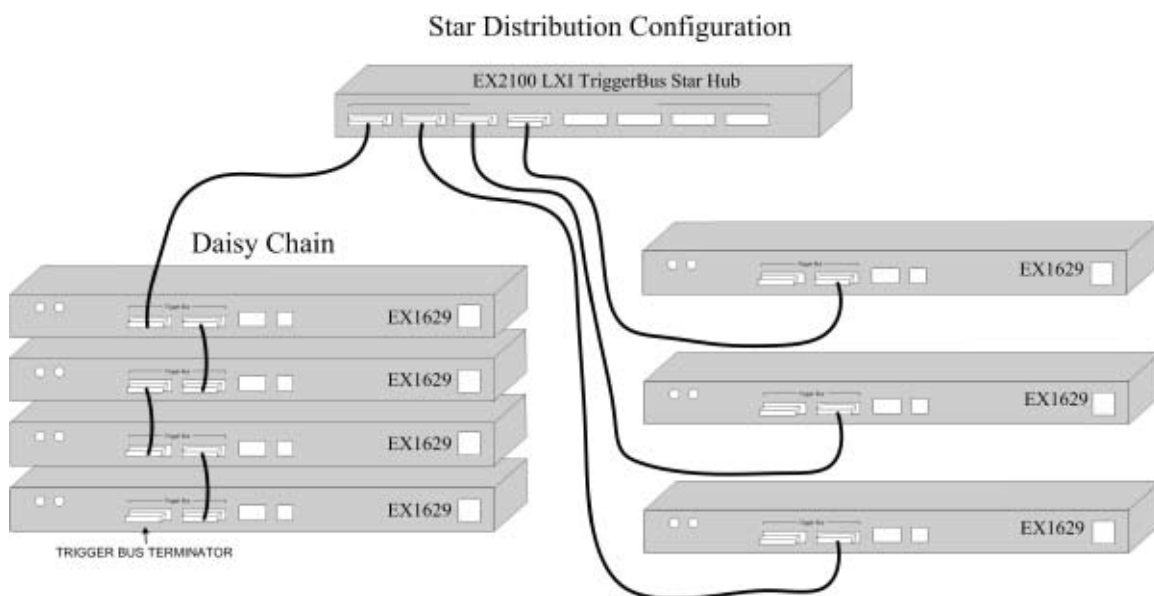


Figure 2.

The TriggerBus can also be automatically extended to other platforms, such as VXI, with a LXI-VXI slot-zero control bridge, providing a mechanism to link a VXI chassis with 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 within the VXI chassis. This type of flexibility will provide the user the ability to integrate other instruments into a homogeneous open test environment, leveraging the strengths of each subsystem.

Summary

Sustainable test platform designs exhibit several common characteristics regardless of the application space that they serve, namely open-hardware and open-software architectures. The computer independent VXIbus platform, for example, continues to be the most widely used modular instrumentation platform in the industry, and since its adoption in 1987 numerous other personal computer (PC) buses have fallen out of favor. Additionally, dependence on the PC based platform flavor-of-the-day will only limit the long term stability of the design. The longevity of LXI-based (LAN) solutions also will buffer a design from the commonly observed volatility of the PC marketplace; computer platforms change approximately every five years. See Figure 3.

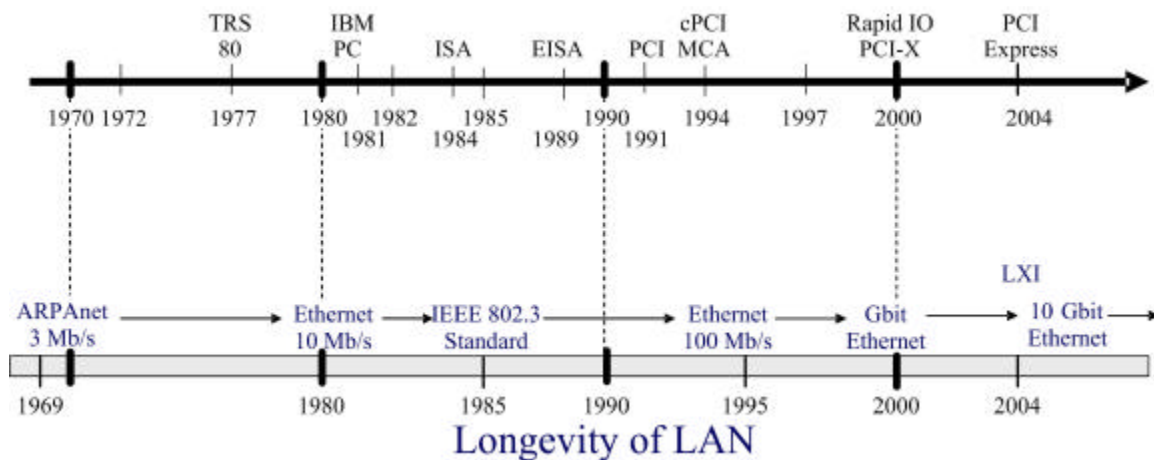


Figure 3.

LXI-based data acquisition and functional test system solutions, such as VXI Technology's EX048 Precision Thermocouple Instrument, EX1629 High-performance Remote Strain Measurement Unit, EX2100 TriggerBus Star Hub, and the EX2500 LXI-VXI Slot-zero Control Bridge ensure the highest degree of forward looking platform compatibility and interoperability. They also ensure that investment capital is maximized by limiting vulnerability to PC and other market conditions that often limit the effectiveness of other proprietary solutions.