VTI Instruments

VTI Instruments Lunch and Learn Seminar

Improving Test Efficiency with LXI

Prepared for the Long Island Chapter of the IEEE Instrumentation & Measurement Society

By Dave Stuart, VTI Instruments

Agenda

- Platform Discussion
- Benefits of LAN as Communications Bus
- Extending LAN to Instrumentation (LXI)
- Understanding LXI Classes
- Application Examples
- LXI Instrumentation for:
  - Data Acquisition and Monitoring
  - Functional Test
  - RF and Microwave Interface Units
- Questions/Hands-On Demonstration
- Quick Intro to VTI Instruments

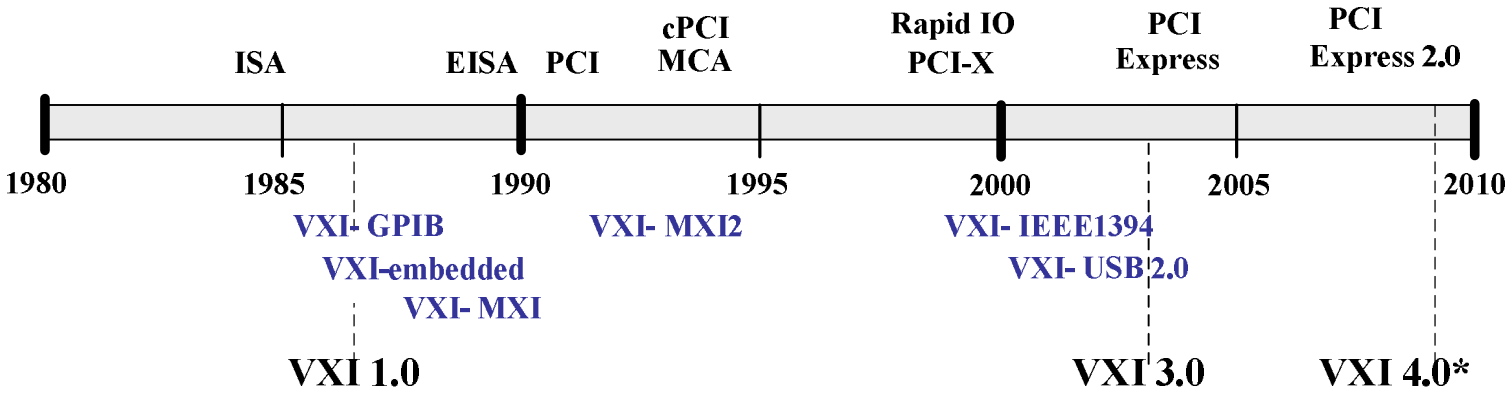
Platforms

Customers Continue to invest in VXI because …..

- VXI is an open platform that continues to be demanded 21 years after its introduction and ensures longevity 15 years into the future.
- No alternative platform provides both the density and product mix the earlier identified market requires.
- VXI provides the power, cooling and size capacity necessary to deliver unmatched measurement integrity and performance.
- A Majority of our VXI products available today have undergone component obsolescence re-designs for longevity and availability

Platforms

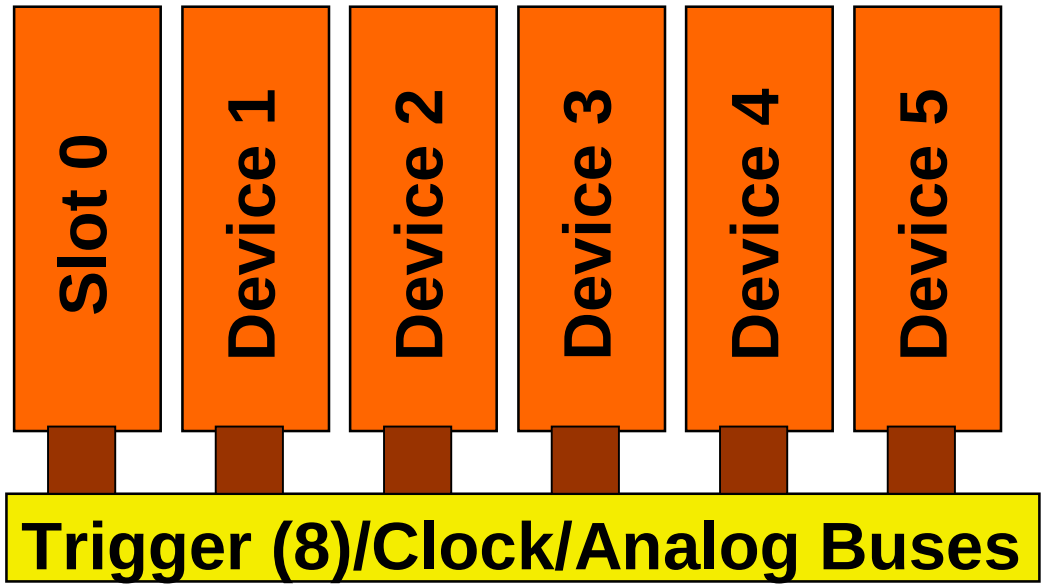
Customers Continue to invest in VXI because …..



- Provides a thick layer of insulation from obsolescence issues inherent to PC bus architecture which ensures test systems will outlive the products that are tested on it

LXI – It’s About Your Time

Mainframe Resource Sharing Benefits



- Shared system clock
- Precision synchronous behavior
- Highly deterministic coordination of asynchronous events
- Shared cooling, power, and communications bus

Benefits of LAN vs. GPIB

§Standard Ethernet I/O

- ØLong Inter-device Connectivity
  - üUp to 100 Meters Point-to-Point
  - üUp to 200 Meters w/Router/Switch
  - üKilometers Utilizing Fiber
- ØSimplifies Cabling
  - üStandard CAT-5
  - üEasy to Route and Install
- ØDevice Interconnect
  - üInexpensive Hubs, Routers, Switches
- ØPC Platform Independence
  - üNo plug-in card required

LXI Overview

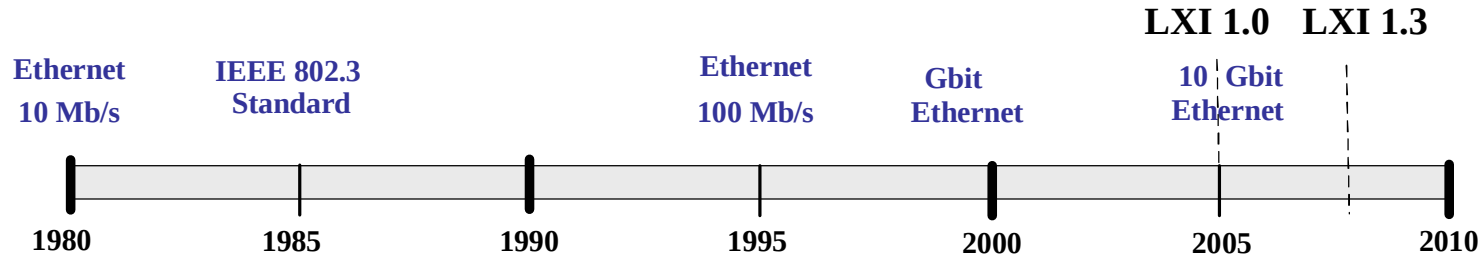
§ Key Functional Areas of LXI Specification

- ØPhysical
- ØDevice Synchronization & Triggering
- ØModule-to-Module Communications
- ØProgrammatic Interface (Drivers)
- ØDevice Discovery
- ØWEB Interface

Platforms
LXI - Instrument Grade Ethernet

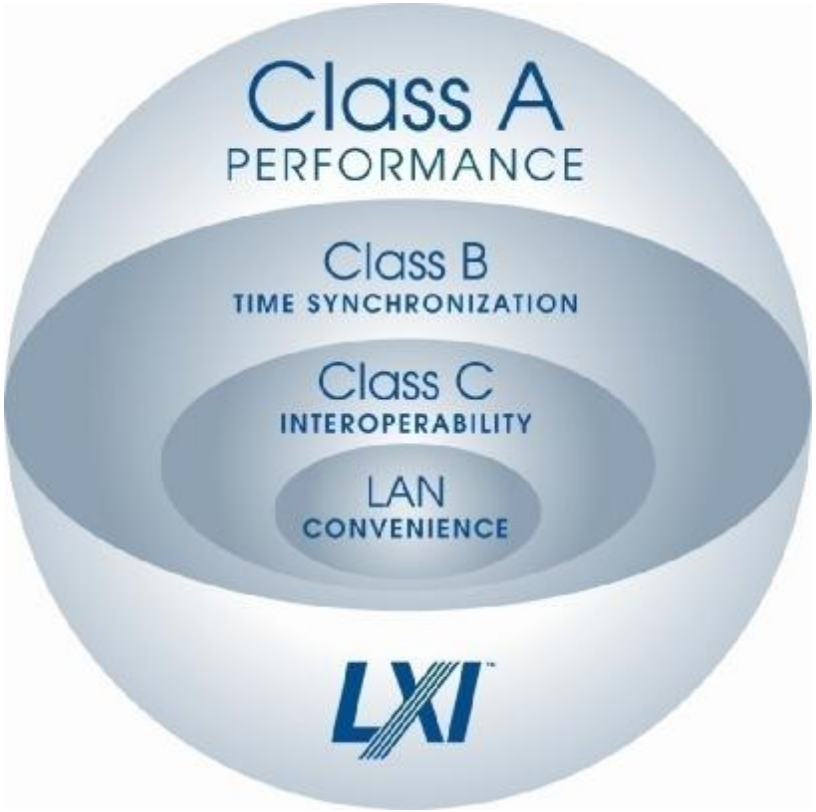
§LXI combines the benefits of GPIB and Ethernet, with the expertise of 50 of the leading instrumentation companies resulting in **ONE** common forward looking instrumentation bus

§VTI and Agilent Technologies created the LXI Standard in response to customer requests for a common, simplified instrumentation bus



- **> $200 M+ Products in 2007**
- **1000+ products on bus**
- **22 vendors have released products**

The LXI Class Hierarchy



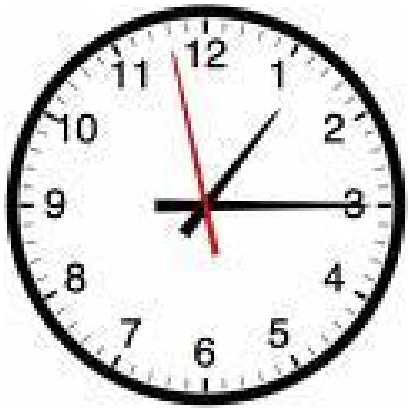
- **LXI Class A Superset Combines…**
- Convenience of LAN
- Guaranteed interoperability
- Precise Time Synchronization
- Backplane-like deterministic behavior

LAN to Class C
Guaranteeing Interoperability

- LAN
  - Ø Ubiquitous communications bus
  - Ø Long history of evolution
  - Ø Readily available infrastructure accessories
  - Ø Low cost of implementation
- LXI Class C
  - Ø Standard specification ensures **multi-vendor interoperability**
  - Ø Common software interface
  - Ø Instrument Discovery
  - Ø Least amount of investment required for class certification
  - Ø Embedded Web Page

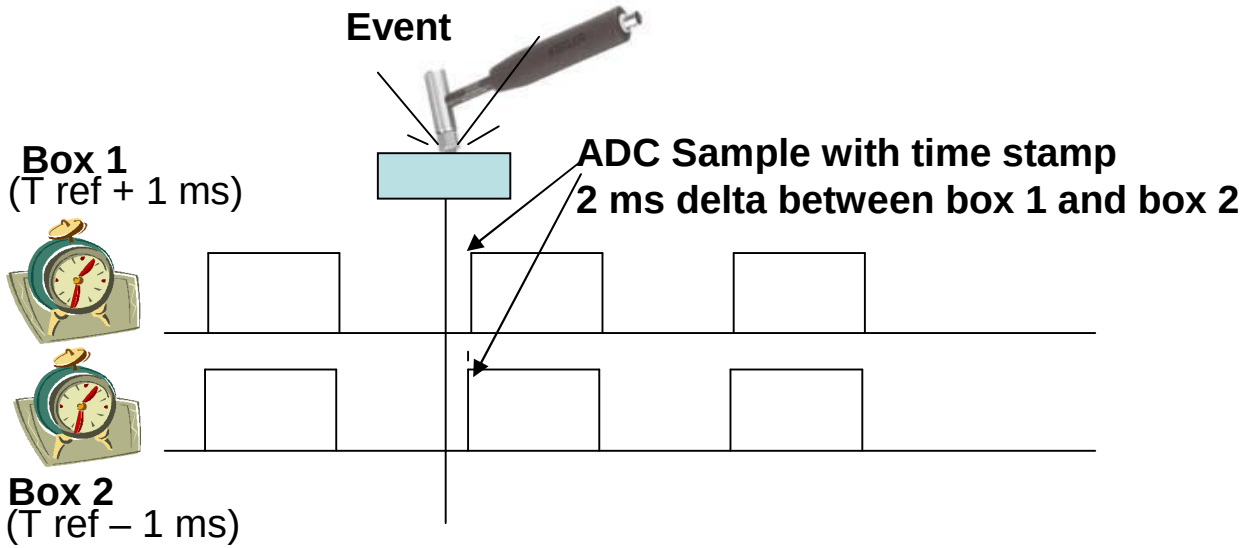
Class C to Class B

Adding a Uniform/Precise Notion of Time



- A notion of time is derived from a counter
- A mainframe based system has a single system clock referenced by all devices
- Devices in a distributed system have independent clocks, counting at different rates depending on pulses/sec
- Differences in time are not constant
  - Cannot be compensated by offset
  - Difficult to time-correlate data
- Class B through IEEE-1588 corrects for any deltas to tens of nanoseconds depending on implementation

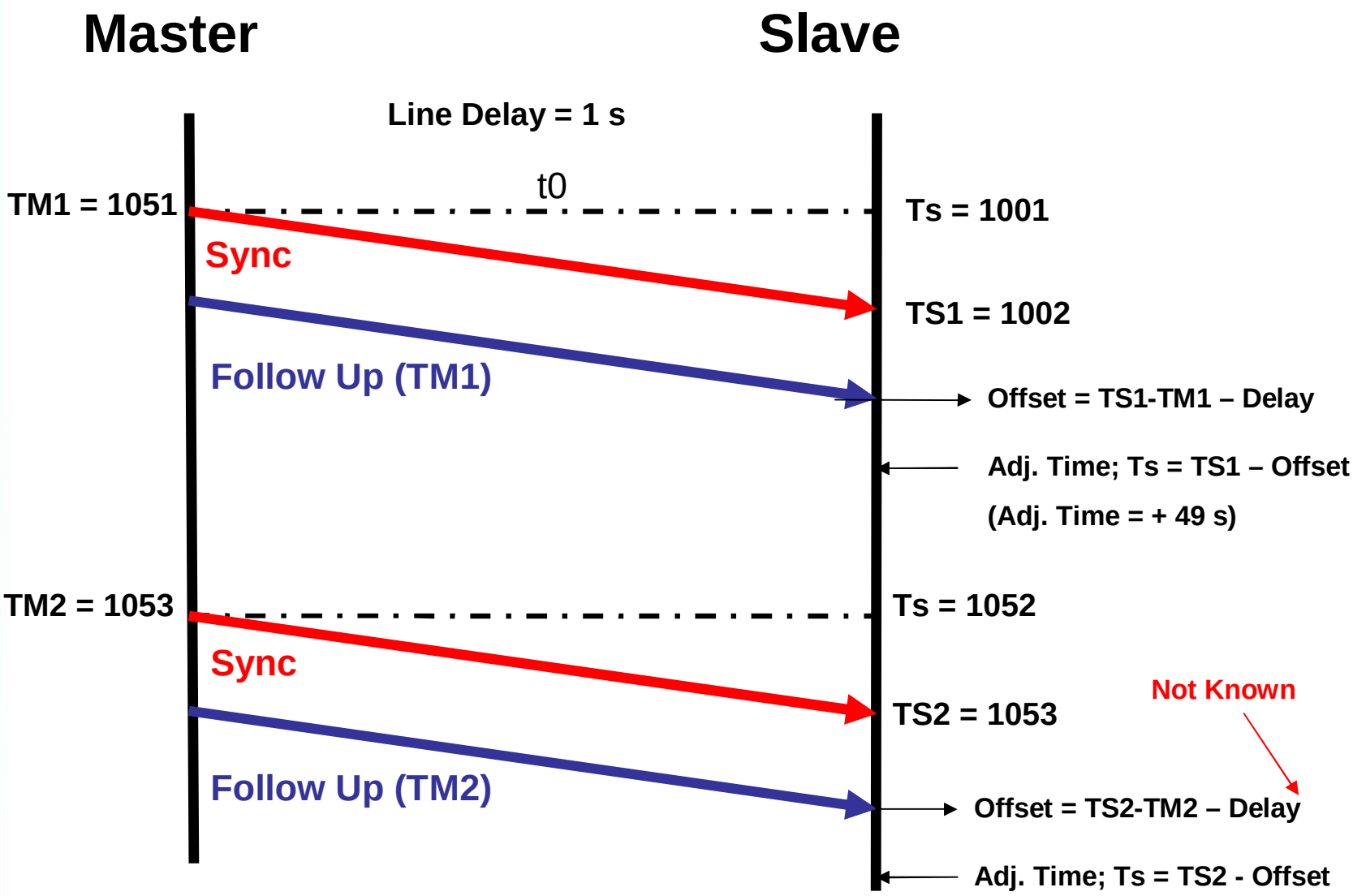
Class B/IEEE-1588 Gets the Time Right



- Free running oscillators in distributed measurement systems have inherent error
  - Ø Causes differences in notion of time
  - Ø Single event can be logged with different time stamps -> difficult to correlate
  - Ø IEEE1588 (PTP) enables precise coordination of **synchronous** events

Class C to Class B

Adding a Uniform/Precise Notion of Time



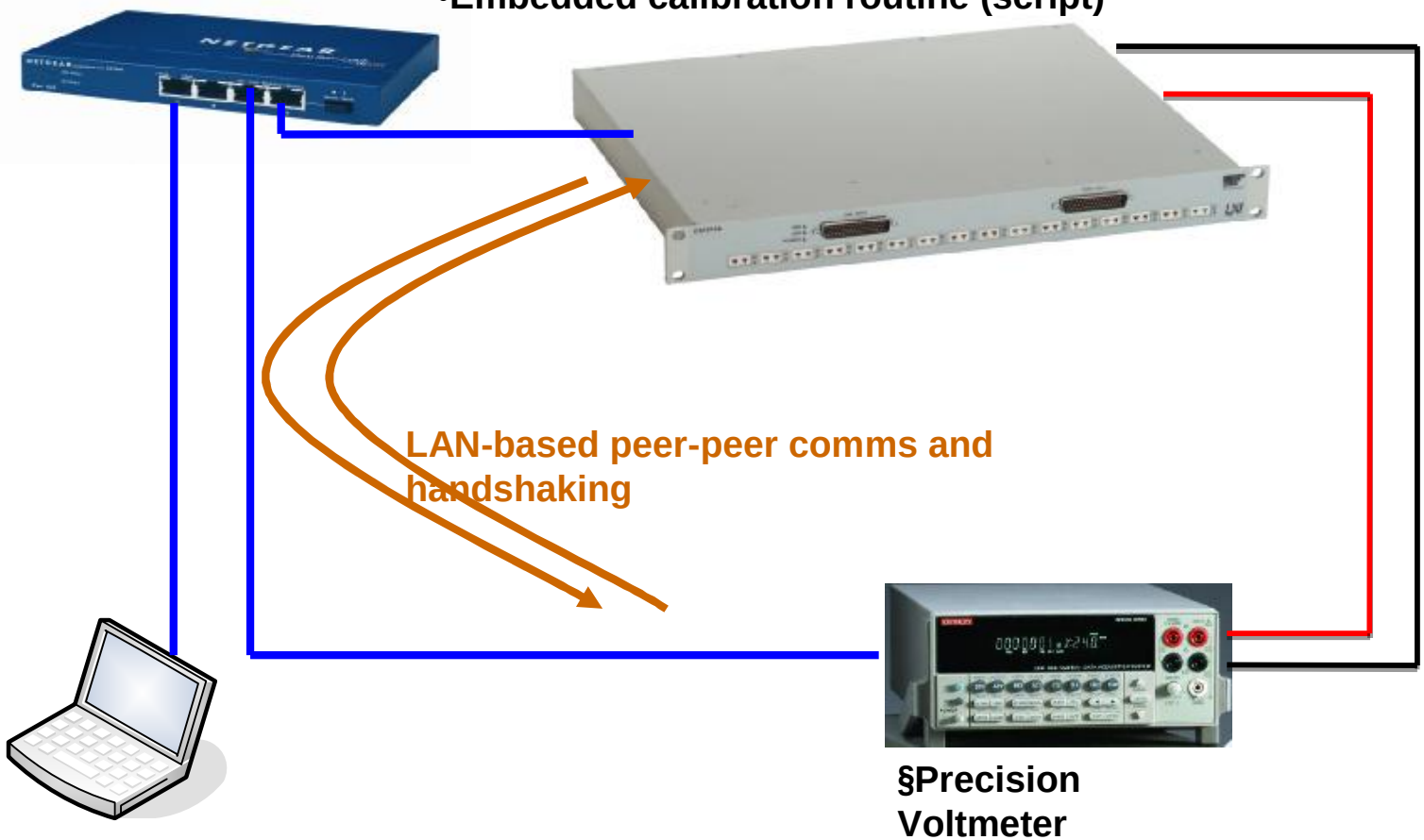
Class C to Class B

It's not just about accurate time stamping

- IEEE-1588 enables synchronous events with high degree of precision
- Time event logs can be used to streamline test sequencing
  - Future events referenced to a common notion of time
- Flexible LAN-based triggering
  - Peer-peer communication
- Embedded test sequences/scripts minimize latency/overhead

Class C to Class B
Facilitating Calibration

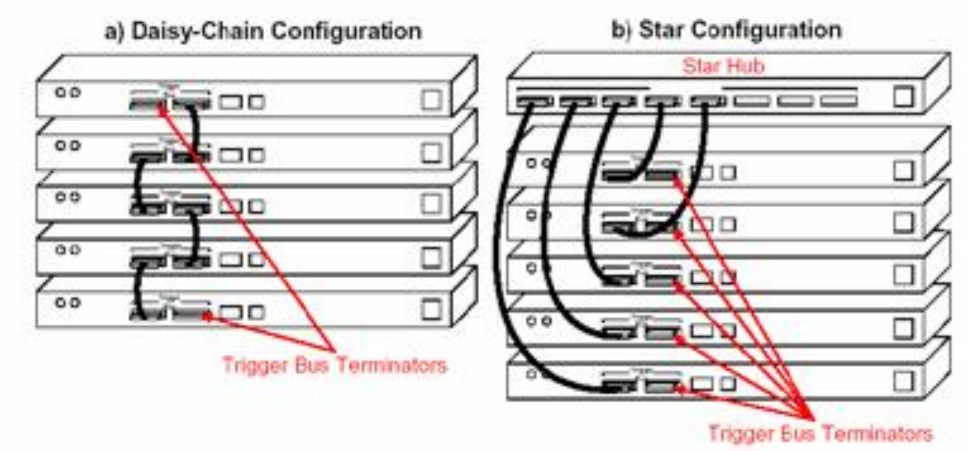
- **Precision t/c and voltage measurement device with internal precision source and self-calibration**
- **Embedded calibration routine (script)**



§Precision Voltmeter

Class B to Class A
Adding a Precision Hardware Based Interface

- **Analogous to VXI and PXI trigger bus**
  - Familiar hardware-based model for triggering and handshaking between discrete modules
  - Eight (8) m-LVDS lines with wired-or operation
  - Supports segmented trigger bus lanes
    - Systems can extend beyond the eight trigger lines



Class A for Deterministic Handshaking

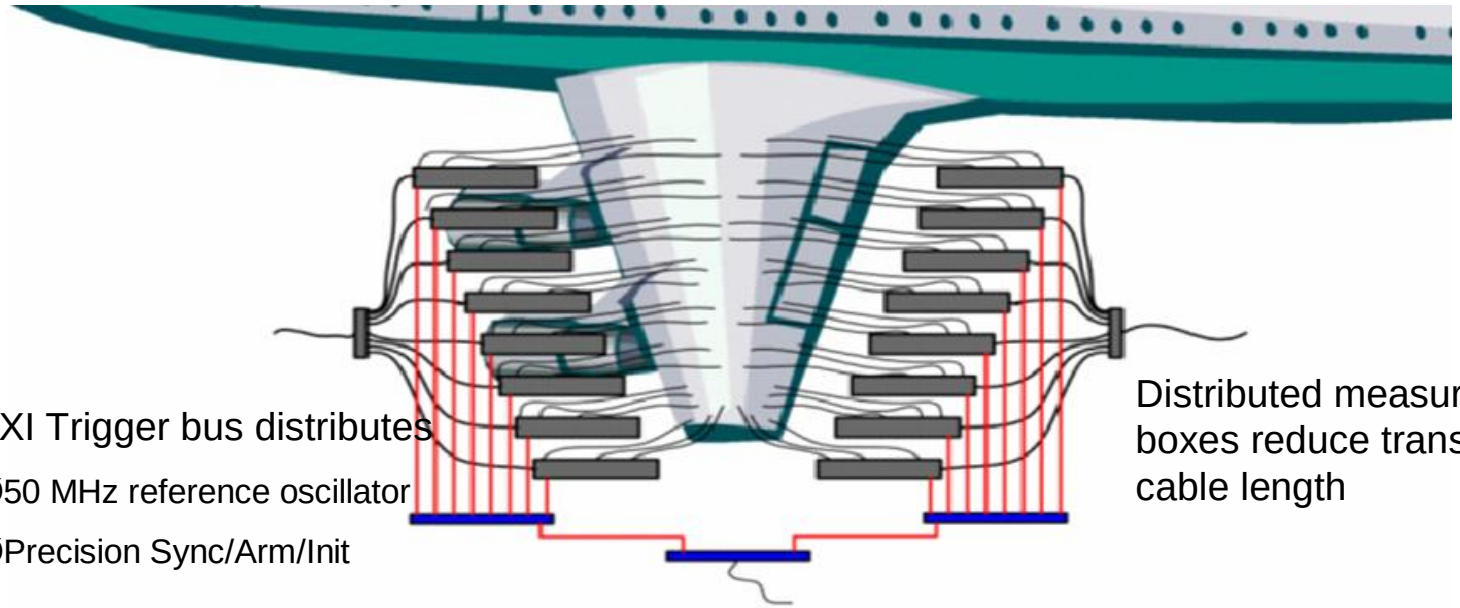
- Used when highly deterministic **ASYNCHRONOUS** hardware handshaking is required
  - Near-zero latency
- Absolute minimal errors in phase alignment
- Distribute physical clock/trigger/sync signals with picosecond resolution
  - Errors are reduced to propagation delays
- Expanders/buffers can be used to extend distance
- Includes LXI Class B requirements by definition
  - Use Class B when high level of determinism is not required or when external trigger bus cabling is not feasible

LXI in Distributed DAQ

- Reduction in wiring
- Integrated Data Acquisition and Signal Conditioning
  - Measurement accuracy
  - System Reliability
  - Cost

Benefits of Distributing Measurements

>10,000 channels of distributed strain measurement in structural test



LXI Trigger bus distributes

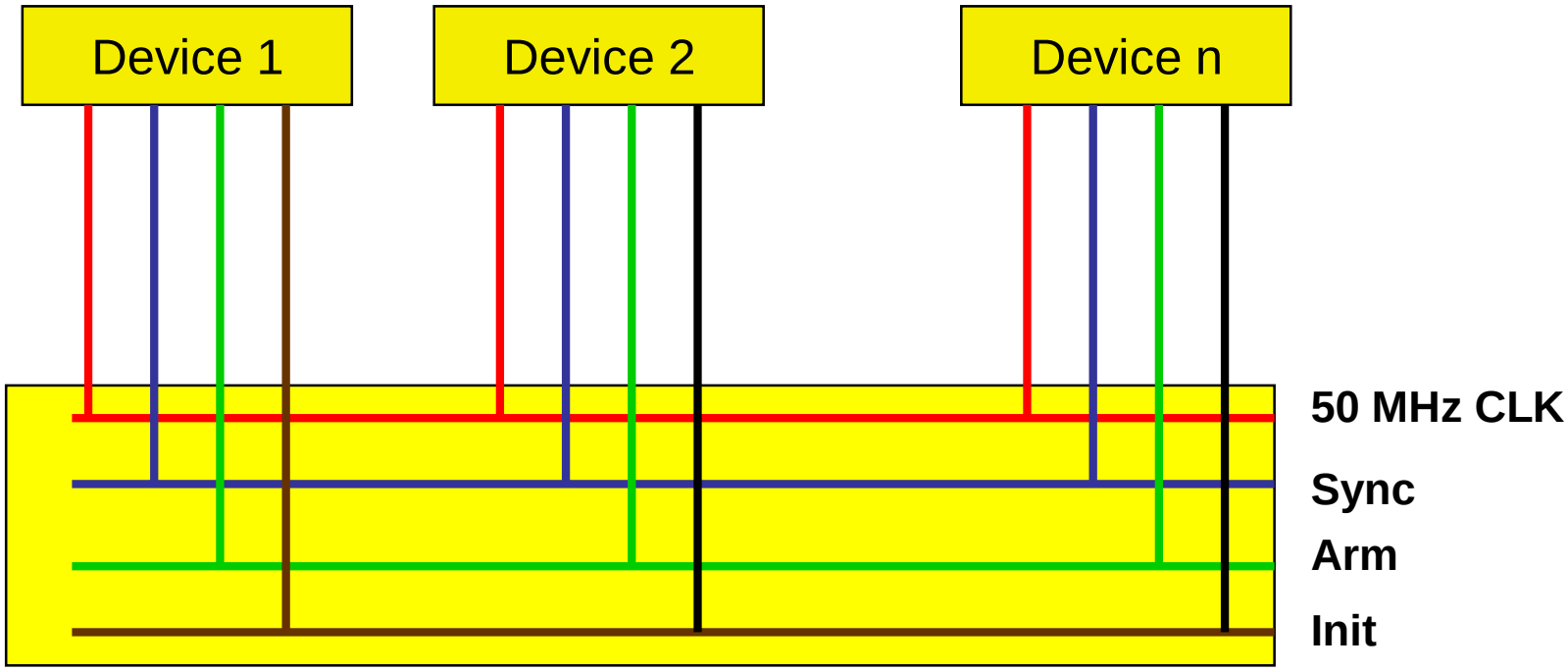
- 50 MHz reference oscillator
- Precision Sync/Arm/Init

Distributed measurement boxes reduce transducer cable length

Single Ethernet Wire back to Host PC

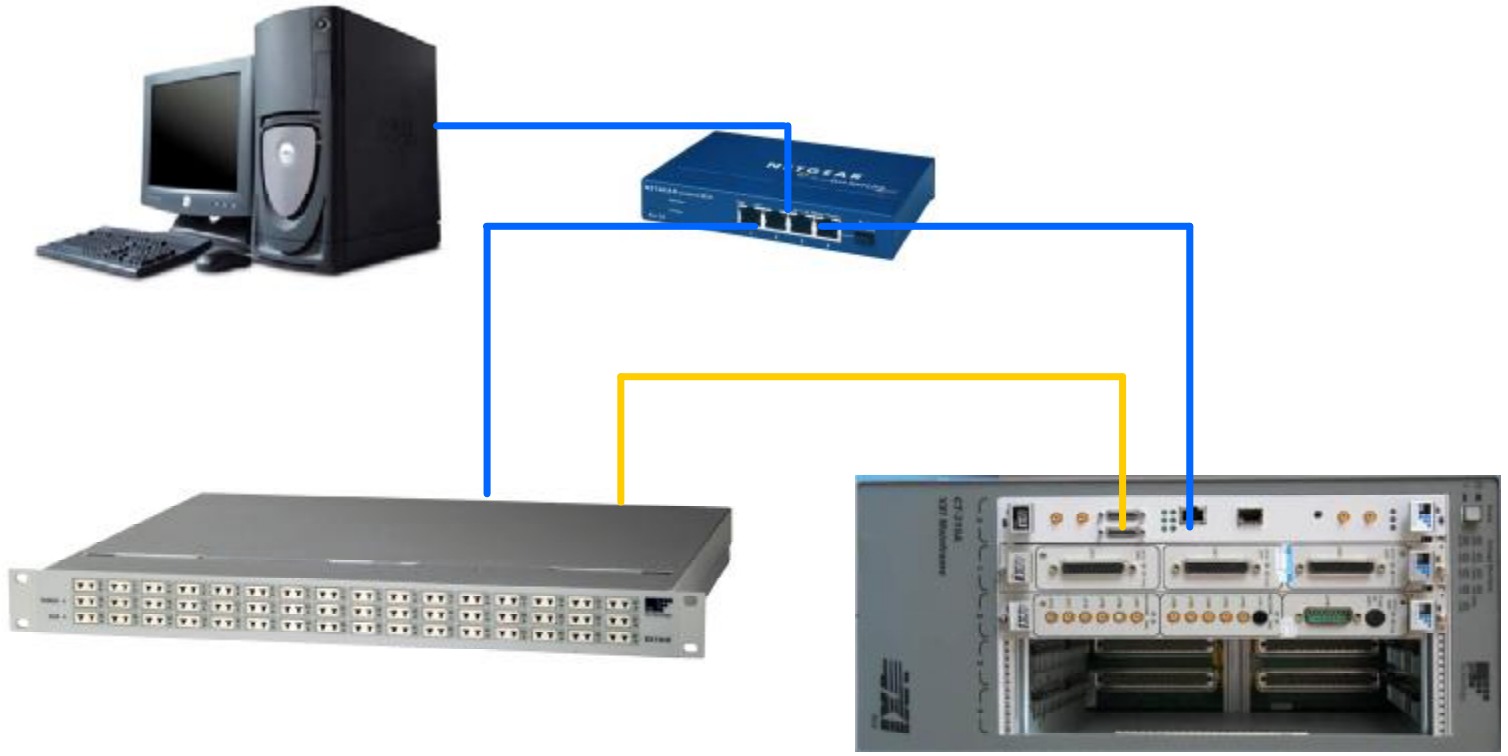
The Distributed Backplane

- Shared trigger bus lines
  - Shared reference clock
  - Asynchronous handshaking
- Uniform notion of time

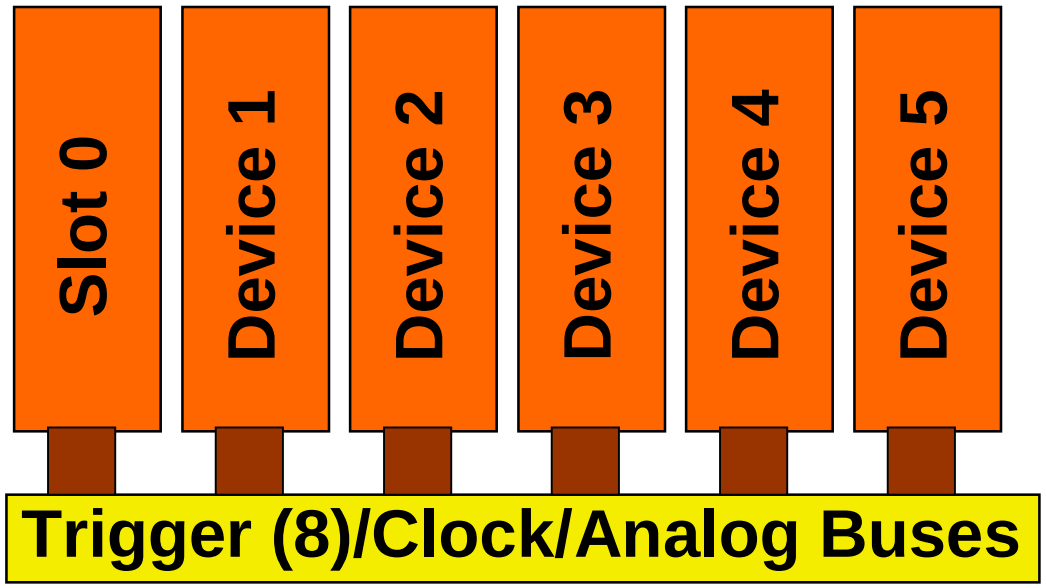


Class A for Hybrid Systems

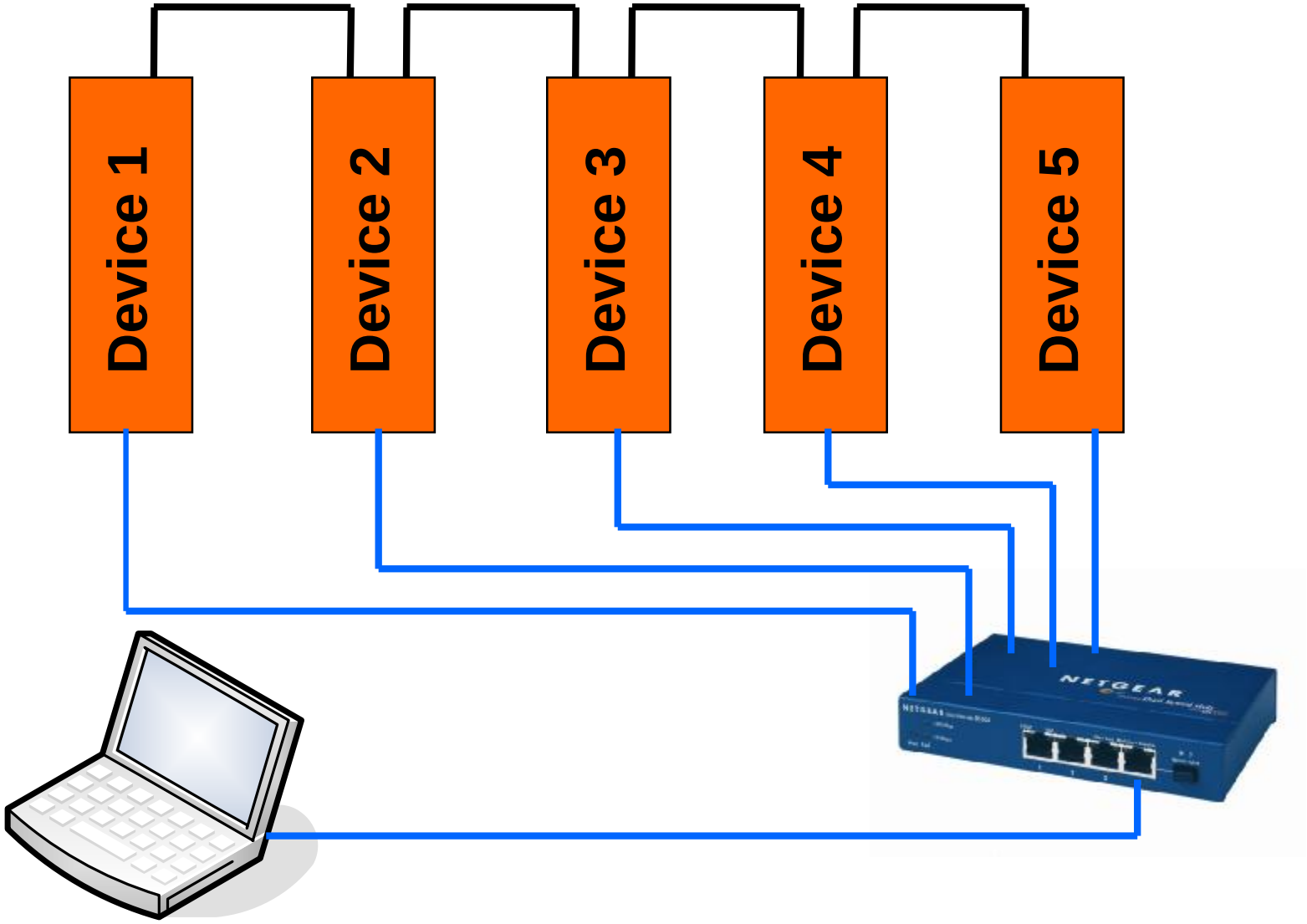
- LXI bridge devices integrate mainframe-based systems with LXI
- Hardware trigger model is common to both architectures
- LAN-based messaging can be converted to hardware triggers



Mainframe Resource Sharing



The LXI ‘Backplane’



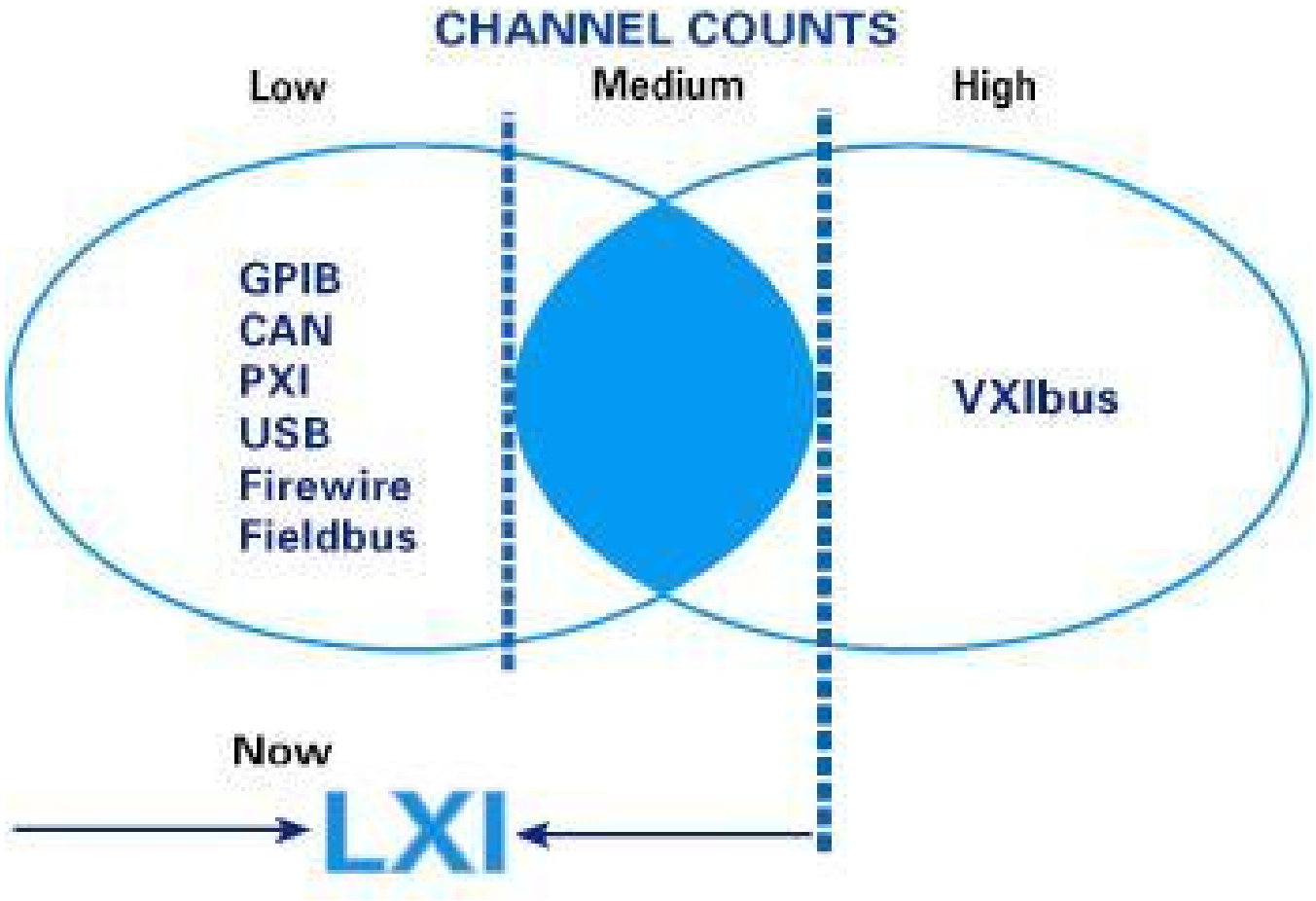
LXI-The Distributed Backplane

- **Highly deterministic synchronous behavior** √
  - LXI Class B – IEEE-1588
- **Precise coordination of asynchronous events** √
  - LXI Class A Trigger Bus
- **Shared system clock** √
  - LXI Class A Trigger Bus
- **Shared cooling, power, and communications bus** √
  - Shared power/cooling is not needed, each LXI device is ‘tuned’ for exact requirements – reduces overhead and cost

AND IT CAN BE DISTRIBUTED!

VTI - Platform Usage

LXI for Small - Mid Channel Density Applications



The EX1200 Series
What is it?

Internal 5-wire bus routes directly to DMM

1/2 rack, 1U with 2-slots

EX1202-Front View

19" rackmount options

Robust Connectors Provide Durable Interface

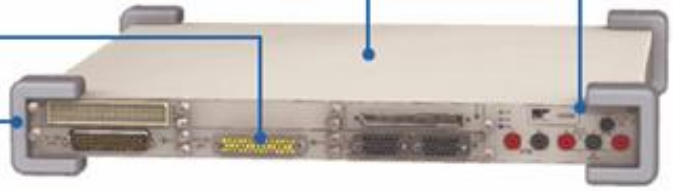
EX1206-Front View

Full-featured 6.5 Digit DMM

Full rack, 1U with 6 slots

Modules plug in from the front – Minimizes system wiring

Optional Benchtop Protective Mounts



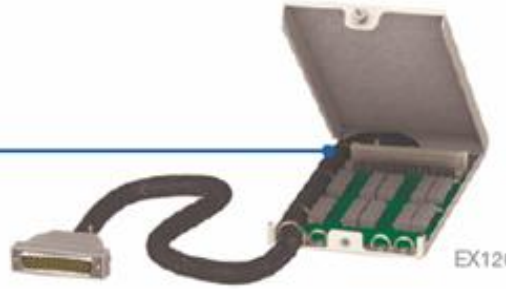
EX1266-Front View

The EX1200 Series
What is it?

Analog Bus Extension
Digital Alarm Outputs
LAN/LXI Status LEDs
Standard LAN connectivity
8-line LXI Class A trigger bus –
Precision hardware handshaking

EX1266-Rear View

Screw terminal block with internal CJC



EX1200-TB104

Full rack, 3U with 12 slots
Optional 16-line high-performance
analog backplane

EX1267

MEASUREMENT INTEGRITY DENSITY & MODULARITY PRODUCT LONGEVITY COST OF OWNERSHIP

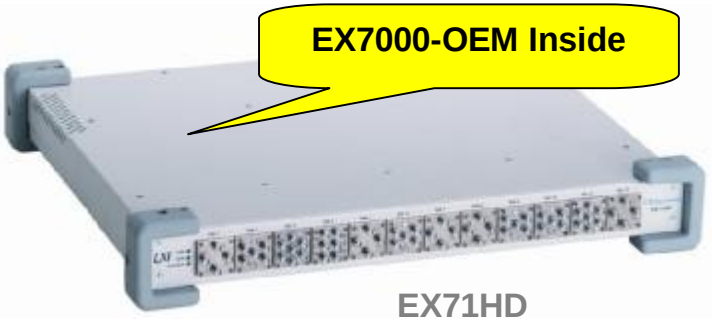
The EX1200 Series
High-Density Switch/Measure Control

Highlights

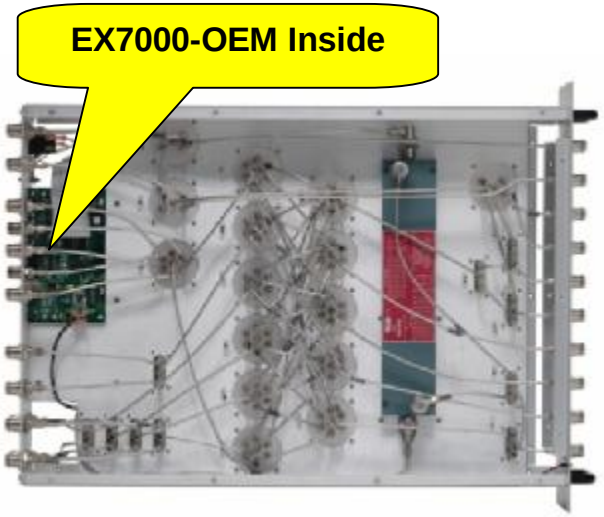
- **Up to 576 channels of measurement in 1U**
- **Measure thermocouples, RTDs, voltages, current, frequency**
- **Embedded scanning software simplifies programming**
- **Switch DC – 3 GHz, low-level to 16 A, 1000 V**
- **Scalable, ½ rack 1U (two plug-ins) to full rack 3U (16 plug-ins)**
- **Analog stimulus (DACs), and digital I/O modules**
- **Timestamp data using LXI Class A, IEEE-1588**
- **DAC Express support**

LXI Class A Microwave Switching

EX72SF



EX71HD



EX7300

EX7000-OEM

EX1016A

EX1000A Family

Precision Thermocouple and Voltage Measurement Instruments

- Is the basic building block used in any test cell or data acquisition application. Allows test engineers to connect directly to the box without using patch panels, making wiring simpler and more reliable.
- Leverages integrated signal conditioning for the **highest measurement accuracy** thermocouple (TC) and voltage data acquisition solution in the market.
  - Real-world accuracies of 0.2 degrees C is ‘best-in-class’

4 distinct LXI Class A products

Ø	EX1000A	48 Voltage Measurement Channels
Ø	EX1016A	16 TC/32 Voltage Measurement channels
Ø	EX1032A	32 TC/16 Voltage Measurement channels
Ø	EX1048A	48 TC Measurement channels

EX1016A

EX1000A Family

Precision Thermocouple and Voltage Measurement Instruments

- **Synchronize Distributed Measurements - LXI Class A Compliant**
  - LXI hardware trigger bus for highest level of synchronization/triggering between distributed devices
  - IEEE1588 offers convenient LAN-based synchronization (messaging)
- **Measurement Integrity - Built-in Self Calibration**
  - Ensures highest level of accuracy prior to each test
  - Yearly calibration only requires a reference DMM
    - Allows for boxes to be calibrated in the environment that they are being used – reduces downtime, increases efficiency
- **Versatile Software Options**
  - Embedded Web Page, Turnkey Software and Driver Support
  - Works in virtually any application development environment and operating system (including Linux)

Powerful Software Solutions

Industry standard IVI drivers

- LabVIEW
- LabWindows™/CVI
- VEE
- C/C++
- Visual Basic

Turnkey Datalogging

- DAC Express

OS Independence

- Windows®
- Linux

In Summary, LXI Instruments…

- Precision Modular Instrumentation
  - **Measurement Integrity**
    - Integrated Hardware and Software - unmatched measurement capabilities, and the Power of LXI
  - **High Density, Modular Solutions**
    - Scalable from low to high channel count, highest densities available while scaling back time-to-market
  - **Design for Product Longevity**
    - Stable platform development
  - **Lowest Lifetime Cost**
    - Support infrastructure of a worldwide company with flexibility and culture of a small business

FAQs and other items of interest

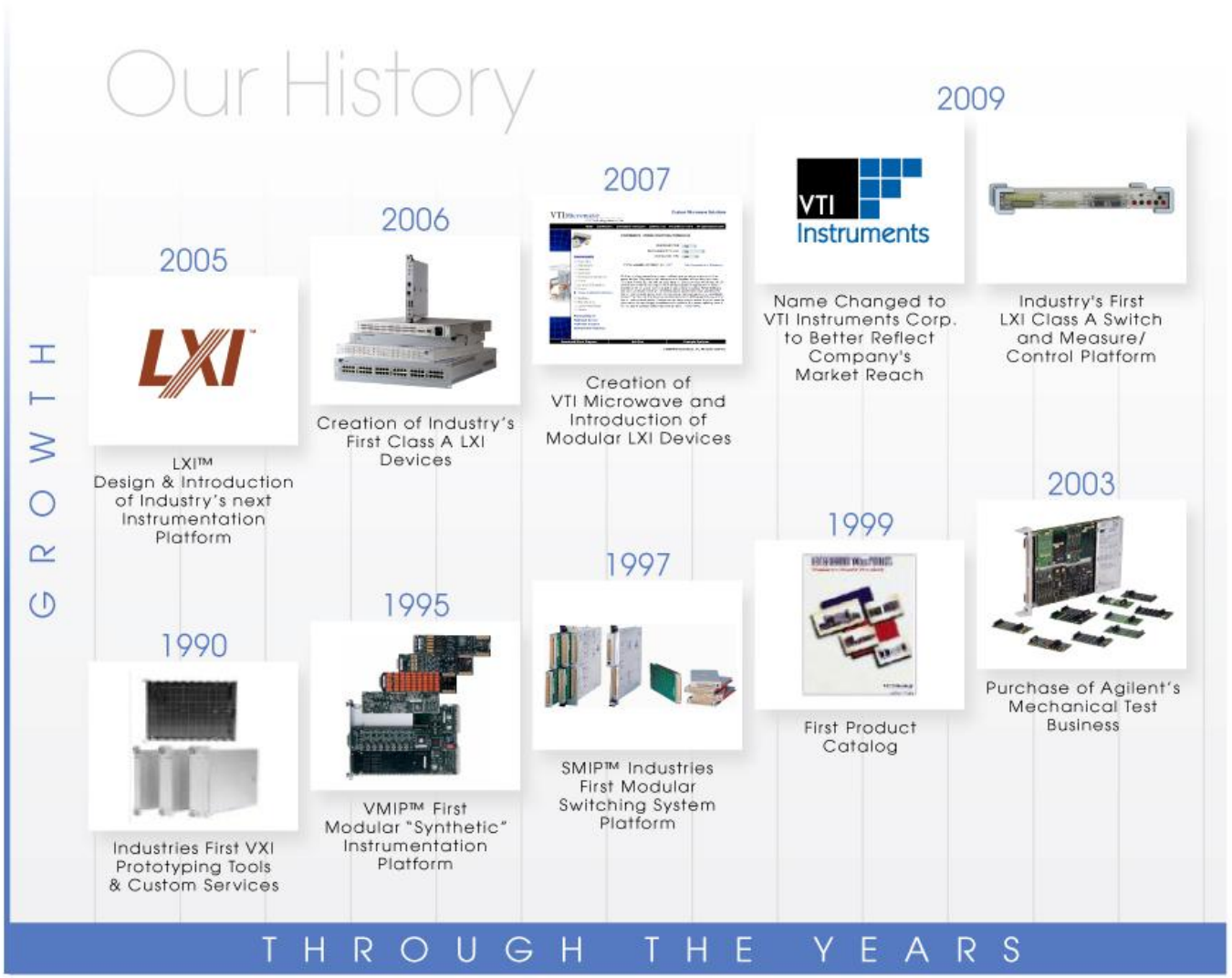
- Can I have LXI Class A, B, C devices plugged into the same network?
  - Yes, in fact, you can have generic LAN instruments as well. LXI ensures interoperability and a common software architecture. It's just that a 'C' device won't be able to synchronize with 'B' or 'A' devices without external hardware. Some companies offer external hardware trigger boxes and IEEE-1588 boxes that make 'C' devices have some 'B' and 'A' capability, but this is added cost. Some 'C' devices may add pieces of 'B' or 'A', but that is up to the vendor. 'A' ensures that you have the best of all worlds (and costs for VTI 'A' implementations are equivalent to 'C' and 'B' implementations from other vendors).
- How many LXI instruments are available
  - This information can be found on the LXI website. There are over 1000 instruments available from 20 vendors, and this list is growing at a rapid pace.
- If LXI Class B and A is so important, why are so few available?
  - This is not uncommon in the first few years of a standards life cycle. The same thing happened with VXI and PXI instruments. If the first few years of those standards, vendors raced to try to fill the demand for products by porting product designs over from existing platforms (in VXI it was VME and GPIB, in PXI it was PCI/cPCI.). The result was that many of the products didn't take advantage of the 'X" (extensions) to leverage the benefits that the new spec had to offer. It wasn't until 8 years after the initial release of the VXI spec that multiple instruments in a slot started showing up (VMIP). In the first few years of the PXI spec, it was difficult to tell the difference between many cPCI and PXI modules. We're fully expecting LXI will follow the same route and more B and A instruments will be released in the upcoming years.

FAQs and other items of interest

- Why does the date on our boxes come up as 1999?
  - We do not have battery backup, so each time the device is powered on/off, any date/time information is lost. It is easy to set this up, though. If the actual date/time is needed, it can be changed on one box, and the target can be set to that box, or all boxes on the network.
- What is the meaning of the large number for IEEE-1588 time that is displayed in the soft front panel? What does that mean?
  - Because the refresh time on computers is slow, we display the IEEE-1588 time in seconds. The resolution is actually nanoseconds, but that would be meaningless to display on the sfp. The number is in reality related to coordinated universal time in which t0 occurred some specific date/time around 1971. The number we display are the number of seconds that have elapsed since that specific date.
- Isn't latency a problem with LXI because it is based on Ethernet?
  - This question usually means that the person asking the question has been exposed to PXI. While it is true that whenever sending a message over the wire, a hit is taken known as 'first-byte latency'. This is due in large part to the overhead of the protocol. However, most next-gen LXI devices are embedding smarts, like the EX1200, where functions such as switch/measure are self-contained and do not rely heavily on the host. As well, LAN-messaging can remove the burden from the host by having modules communicate to each other over the wire. Additionally, In many applications (switch/measure is a good example), the instrument settling time is the bottleneck (first byte latency is roughly 250 us or so and switches settle in 3 ms or more). It is application specific, and in many cases, streaming data interfaces also minimize the first-byte latency effect. Still, 10,000 transactions between host and the instrument would have to occur to add 1 second to the overall test time.

Introducing VTI Instruments

Merging the Legacy of Agilent Mechanical Test Group with the Stability of VXI Technology

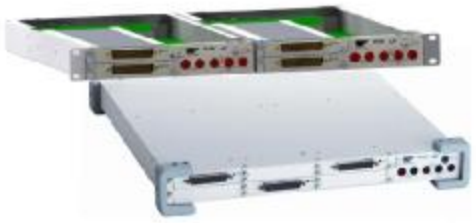


VTI - What We Do

- VTI designs and manufactures precision high-density instrumentation on open-architecture platforms.
- A growing portfolio of over 200 products that addresses electronic and mechanical test applications.
- The business units (product groups) address the following areas:
  - **Functional Test**
  - **Integrated Data Acquisition and Signal Conditioning**
  - **Dynamic Signal Analysis**
  - **Custom Microwave Subsystems**

Functional Test Instrumentation & Switching
Based on Open Industry Platforms – VXI, LXI and VME

- ü Time Stamp
- ü DMM
- ü Digitizer
- ü AWG/FG
- ü D/A
- ü A/D
- ü Comparator
- ü Counter
- ü Digital IO
- ü Relay Driver
- ü Serial IO
- ü Prototyping



- ü Matrix
- ü Multiplexers
- ü Low level
- ü High power
- ü Splitters
- ü Loads
- ü Optical
- ü RF
- ü uWave
- ü Custom

Static and Dynamic Data Acquisition

Ø Digitizers, Signal Sources, Signal Conditioning, & Control

- ü **Temperature**
- ü **NVH**
- ü **Signal Analysis**
- ü **Strain**
- ü **Acoustics**
- ü **Vibration**
- ü **Pressure**
- ü **Modal**

- ü **Wind Tunnel Dynamics**
- ü **Rotating Machinery**
- ü **Acoustic Chamber Control**
- ü **Vibration Control**
- ü **Real-time Octave**
- ü **Signal Conditioning**

MEASUREMENT INTEGRITY DENSITY & MODULARITY PRODUCT LONGEVITY COST OF OWNERSHIP