LAN eXtensions for Instrumentation (LXI™): Revolutionizing Calibration

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Introduction

Test and measurement instruments are used in a wide array of applications including satellites, rocket engines, automotive engines, and medical devices. While the signals of interest for each application require different test methodologies, the common thread that binds them together is the reliance on repeatable and accurate test results. Unreliable test results can result in schedule setbacks, substantial monetary losses, and endangerment to human safety. Because of the high cost of failure, it is critical that test engineers use their measurement devices to produce consistent test results with high data integrity.

Measurement integrity is achieved through instrument calibration and traceable verification standards. The accuracy of data returned by an analog input device, for example, is verified by measuring a highly accurate and traceable source that is connected to the inputs of the instrument under test. Typically, this is viewed as a painful yet necessary process involving station disassembly and downtime. Test engineers are required to disassemble test stations and send each individual product to their respective vendor's factory for calibration. Some costly workarounds to this procedure include ordering spare instruments for each test station, hiring an outside calibration service, or constructing an in-house calibration laboratory.

This paper demonstrates how LXI Class A instruments simplify instrument calibration for test engineers, which reduces the cost of calibration and test system downtime.

What is LXI?

The LXI specification extends the capabilities of Ethernet by addressing key functional areas that are necessary to ensure instrument interoperability, performance and usability. The specification is divided into three classes: A, B and C. The minimum requirements to achieve class certification at each level are clearly defined. Class A encompasses all the benefits of LXI and is the class of choice for systems that require instrumentation to be tightly integrated and synchronized.

LXI test and measurement modules are optimized for use in design validation and manufacturing test systems with LAN connectivity, enabling modules to be accessed from anywhere in the world. Unlike modular card cages that heavily depend on a host controller, LXI modules incorporate an internal processor, LAN connections, a power supply, and trigger inputs. These attributes provide a mechanism for instrument-to-instrument communication that is completely independent of a host controller. When compared to legacy test and measurement standards, this concept opens the door to a variety of revolutionary application strategies.

Leveraging the Benefits of LXI for Calibration

Unlike products designed on GPIB, PXI, VXI, or proprietary platforms, LXI Class A products provide:

- Built-in web servers
- An industry standard that defines triggering and synchronization between stand-alone instruments
- Peer-to-peer communication
- Remote access to instruments from anywhere in the world

- Logging and distribution of instrument attributes and test/calibration data over the web

LXI Class A-compliant products are capable of synchronized peer-to-peer communication, which can remove the burden of coordinating and managing the calibration verification process from an external host controller. Instruments that are designed with on-board precision voltage references are the key to making the calibration process more convenient and reliable. The precision voltage source can be connected internally to the analog input path. It is used to ensure a high degree of measurement integrity as part of a “self-calibration” that the user can initiate at any time. This process is enhanced by an easy-to-use calibration routine that is embedded directly into the product’s firmware, allowing the user to execute a complete calibration in minutes with the click of a button. This on-board procedure results in a high degree of confidence in the test data. It also negates any inaccuracies that may be introduced by changes in ambient temperatures from uncontrolled environments.

A Practical Application - Temperature Measurement

The following is an application of an LXI Class A-compliant product being used for temperature measurement. The EX1048A is an LXI Class A-compliant precision thermocouple and voltage instrumentation package offered by VTI Instruments. It uses Class A peer-to-peer device communication and triggers measurements via its LAN interface. The fully integrated web interface and built-in internal voltage reference streamline the calibration process, making it a turnkey solution.

The EX1048A’s embedded web interface is shown in Figure 1. This page can be accessed by typing its unique IP address into the address bar of any W3C browser. The EX1048A’s internal precision reference source is used to self-calibrate the analog input circuitry and is accessible via back panel connectors. A full calibration, which is usually required on a yearly basis, consists of connecting a traceable measurement device to these connectors and verifying the accuracy of the on-board source.

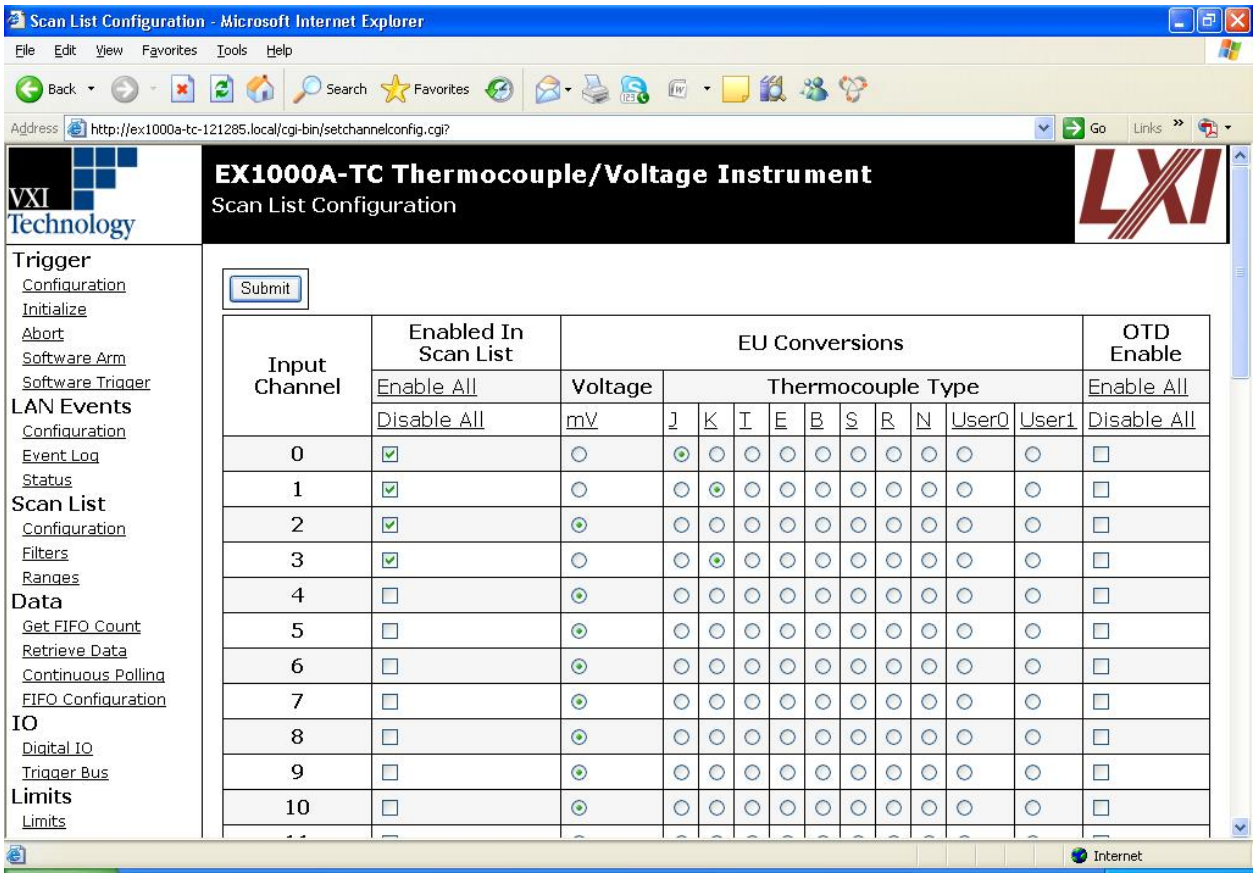

Figure 1 – LXI Embedded Web Interface (EX1000A-TC)

Required Hardware For Full NIST Traceable Calibration:

- Host computer
- NIST traceable precision voltmeter
- EX1048A (unit to be calibrated)

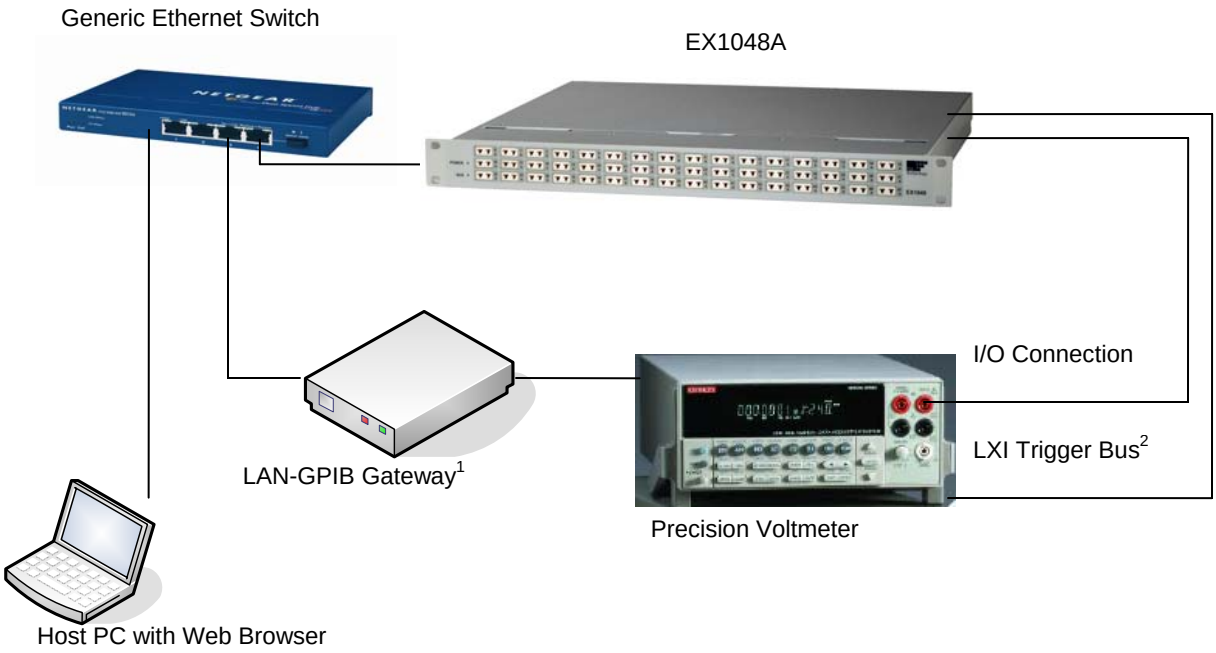

Figure 2 – LXI-Enhanced Calibration Setup

Procedure for Initiating Calibration:

1. Connect the host computer, traceable calibration standard, and device to be calibrated through a LAN hub or switch (Figure 2).

Note 1: A LAN-GPIB gateway is only required for voltmeters that are not LXI-compliant.

2. Connect the voltmeter inputs to the EX1048A precision source output connectors (Figure 2).

Note 2: If the voltmeter is LXI Class A-compliant, also connect the LXI trigger bus between the two devices.

3 Access the EX1048A's web interface via web browser by entering its IP address (Step 1, Figure 3).

4 Select the specific model of the traceable voltmeter from the pulldown menu (Step 2, Figure 3).

5 Enter the IP address of the voltmeter (Step 2, Figure 3).

6 Click a button on the web interface to perform full calibration (Step 3, Figure 3).

The EX1048A's processor manages the calibration procedure. It also contains the calibration program, which includes the commands that are recognized by the specific voltmeter selected from the pulldown menu. These commands are sent across the LXI communications bus as part of the automated process. The total calibration time can be further reduced by implementing the LXI trigger bus, which permits intermodule synchronization and delays of only picoseconds via hardware handshaking. Any adjustments required to ensure that the EX1048A is within its specified limits occur internal to the device.

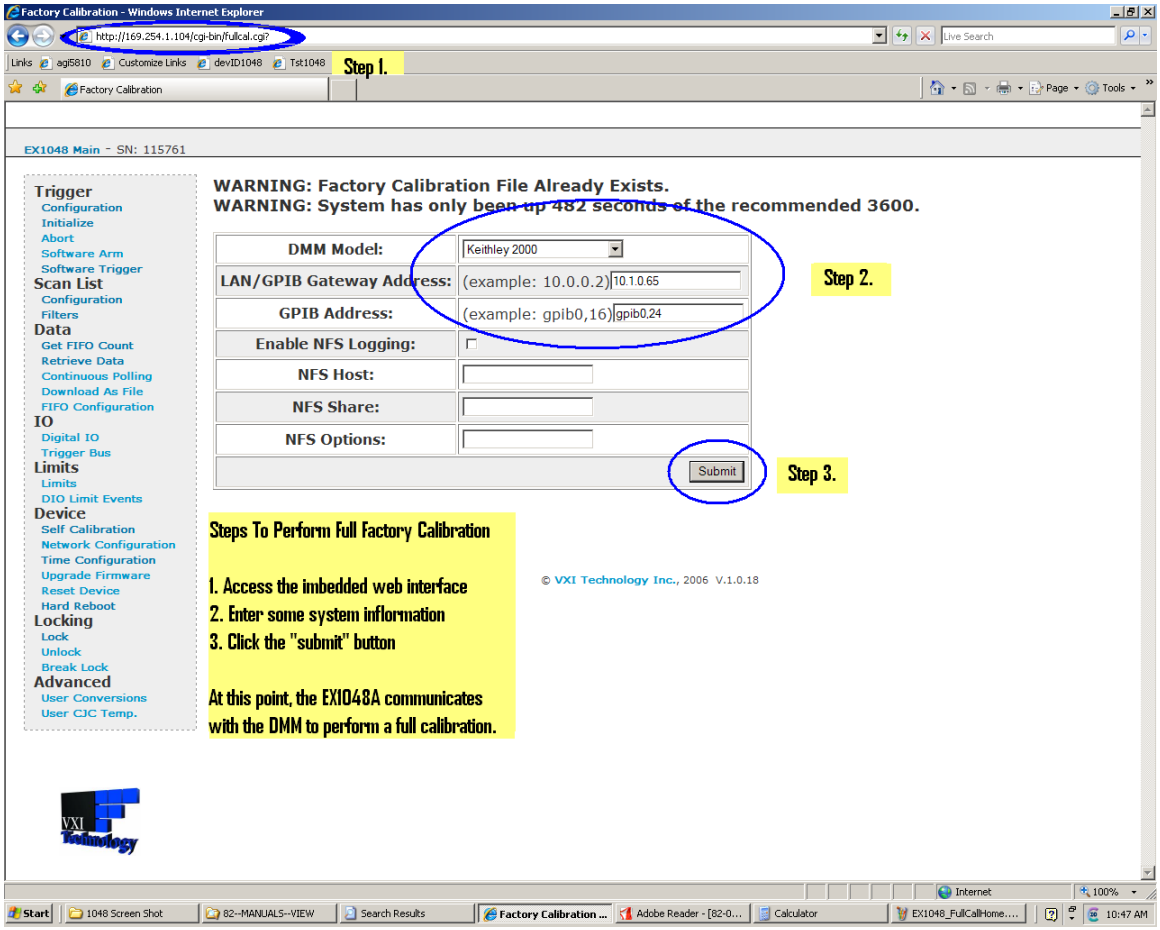

Figure 3 – Full Calibration Web Interface

When compared to other approaches, the calibration process requires minimal user interaction without any calibration software development. The calibration program is internal to the box as part of its firmware, which is controlled by the vendor. The simplified equipment setup enables the process to be executed almost anywhere.

Confidence in Data with Routine Self-Calibrations

Instruments that include a turnkey full calibration procedure provide the highest level of measurement accuracy prior to each data acquisition sequence. Typically, they are designed with a self-calibration procedure that is executed directly from the instrument driver API or the web interface. Before any measurement is taken, users can initiate a self-calibration sequence to route the precision source back through the input signal paths of the instrument. This process makes minor gain and offset adjustments to the signal path. Self-calibration can be executed whenever the device undergoes changes in its surrounding thermal environment to ensure the highest degree of measurement quality.

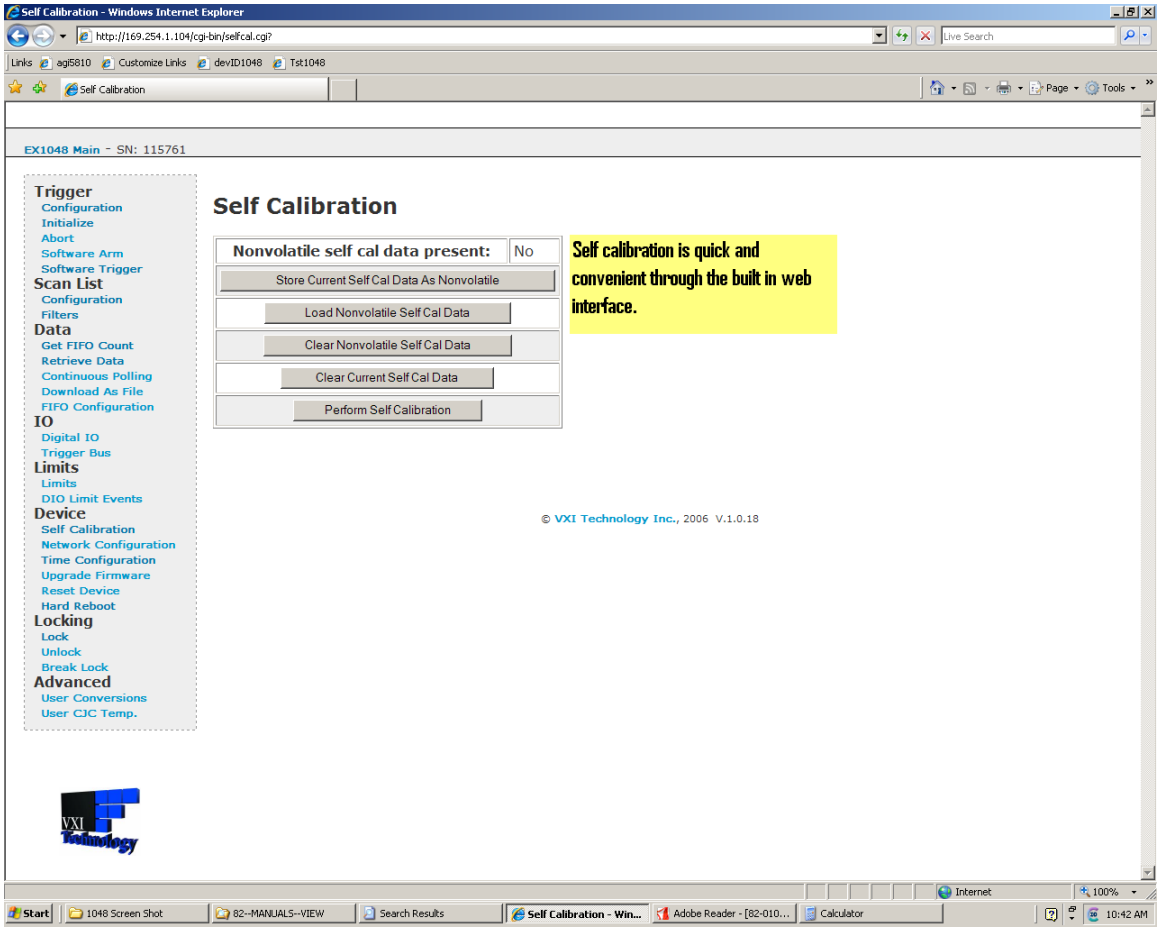

Figure 4 – Self Calibration Web Interface

Continuing with our example, the EX1048A instrument was configured to take Type E thermocouple measurements and then connected to a precision thermocouple simulator. The following table quantifies the benefits of having a routine self-calibration procedure built into your instrumentation. This evidence shows significant improvement in the data quality after the self-calibration is performed.

Accuracy Analysis of EX1048A Before Self-Calibration							
Precision Source	-100° C	0° C	100° C	300° C	500° C	700° C	900° C
EX1048A Measurement 1	-100.60° C	-0.50° C	99.58° C	299.62° C	499.41° C	699.33° C	899.25° C
EX1048A Measurement 2	-100.61° C	-0.51° C	99.59° C	299.63° C	499.40° C	699.34° C	899.26° C
EX1048A Measurement 3	-100.62° C	-0.52° C	99.57° C	299.59° C	499.42° C	699.35° C	899.25° C
EX1048A Measurement 4	-100.61° C	-0.50° C	99.58° C	299.60° C	499.41° C	699.33° C	899.24° C
EX1048A Measurement 5	-100.60° C	-0.51° C	99.58° C	299.61° C	499.41° C	699.34° C	899.24° C

Accuracy Analysis of EX1048A After Self-Calibration							
Precision Source	-100° C	0° C	100° C	300° C	500° C	700° C	900° C
EX1048A Measurement 1	-100.17° C	-0.17° C	99.82° C	299.84° C	499.83° C	699.84° C	899.80° C
EX1048A Measurement 2	-100.16° C	-0.14° C	99.84° C	299.83° C	499.84° C	699.82° C	899.81° C
EX1048A Measurement 3	-100.17° C	-0.15° C	99.83° C	299.83° C	499.84° C	699.83° C	899.80° C
EX1048A Measurement 4	-100.18° C	-0.15° C	99.84° C	299.83° C	499.83° C	699.84° C	899.81° C
EX1048A Measurement 5	-100.17° C	-0.17° C	99.85° C	299.82° C	499.83° C	699.84° C	899.80° C

VTI has ensured that the benefits and advantages of calibration and measurement integrity are an integral part of all its next-generation products. These exciting features are included in VTI's EX1048A precision thermocouple device and the EX1629 static strain measurement device. Devices from other manufacturers that design products based on the LXI standard are listed on the LXI website.