EX1403A

16-CHANNEL
BRIDGE/STRAIN BENCHTOP DIGITIZER

USER'S MANUAL

P/N: 82-0161-000
Released December-2020

AMETEK Programmable Power
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About AMETEK

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AMETEK, Inc. is a leading global manufacturer of electronic instruments and electromechanical devices with annualized sales of over $5 billion. The Company has over 15,000 colleagues working at nearly 150 manufacturing facilities and nearly 150 sales and service centers in the United States and 30 other countries around the world.

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CERTIFICATION

VTI Instruments (VTI) certifies that this product met its published specifications at the time of shipment from the factory. VTI further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY TERMS

The product referred to herein is warranted against defects in material and workmanship for a period of three (3) years from the date of shipping of the product from Ametek facility.
AMETEK Programmable Power, Inc. ("AMETEK"), provides this written warranty covering the Product stated above, and if the Buyer discovers and notifies AMETEK in writing of any defect in material or workmanship within the applicable warranty period stated above, then AMETEK may, at its option: repair or replace the Product; or issue a credit note for the defective Product; or provide the Buyer with replacement parts for the Product.
The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product, or any part thereof, is as follows:

- damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- installed or operated contrary to the instructions of AMETEK;
- opened, modified, or disassembled in any way without AMETEK's consent;
- used in combination with items, articles or materials not authorized by AMETEK.
- Preferably, Customer shall send back the product in their original packing,

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

PRODUCT RETURN PROCEDURE

Request a Return Material Authorization (RMA) number from the repair facility (**must be done in the country in which it was purchased**):

- **In the USA**, contact the AMETEK Customer Service Department prior to the return of the product to AMETEK for repair:

Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)
858-450-0085, ext. 2295 or ext. 2463 (direct)

- **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor, or on our website, https://www.powerandtest.com/service-and-support/rma/rma-request-form.

When requesting an RMA, have the following information ready:

- Model number
- Serial number
- Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.
NOTE: A returned product found upon inspection by AMETEK to be in specification is subject to an evaluation fee and applicable freight charges.

AMETEK®
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Declaration of Conformity

This is to declare that the product listed below conforms to the relevant requirements of the Electromagnetic Compatibility directive (European Council directive 2014/30/EU; generally referred to as the EMC directive), to the requirements of the Low Voltage directive 2014/35/EU, dated 26 February 2014, and to the RoHS2 Directive (European Council directive 2011/65/EU dated 08 June 2011). In substantiation, the products were tested and or evaluated to the standards shown below

Product Type	Product Model Number(s)	Conforming to Standards:
16CH BRIDGE/STRAIN BENCHTOP DIGITIZER	EX1403(XYZ) (XYZ) may represent any combination of alpha numeric characters from 0 to 9, A to Z denoting non safety critical options.	EN 61326-1:2013 EN 61010-1:2010 EN 50581-1:2012 See page 2 & 3

Signature:	Date: 9/1/2020
Name: Barry Palmatier Title: Compliance Engineer	First Issued: March 28, 2019 Doc. Part No:

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Applicable Standard	Applicable Test	Frequency range/ Class/ Test level	Applicable port	Results- Criterion
CISPR 11 (Edition 6.1)2015+AMD1:2016-06 CSV	Radiated emissions test	30 MHz to 1 GHz Class A/ Group 1	Enclosure	PASS*
CISPR 11 (Edition 6.1)2015+AMD1:2016-06 CSV	Conducted emissions test	150 kHz to 30 MHz Class A/ Group 1	Power port	PASS**
IEC 61000-3-2 (Edition 4.0) (2014-05)	Harmonics Current emissions test	Class 'A'	Power port	PASS
IEC 61000-3-3 (Edition 3.0) (2013-05)	Voltage Fluctuations and Flicker emissions test	As per Clause-5 IEC 61000-3-3	Power port	PASS
IEC 61000-4-2 (Edition 2.0)(2008-12)	Electrostatic Discharge immunity test	CD: Level-4/± 8kV AD: Level-3/±8kV	Enclosure	PASS Criterion 'A'
IEC 61000-4-3 (Edition 3.2) Consol. with Amd. 1 &2 (2010-04)	Radiated immunity test	80 MHz to 1 GHz Level-2/ 3V/m 1.4 GHz to 2GHz Level-2/3V/m 2GHz to 2.7GHz Level-1/1V/m	Enclosure	PASS Criterion 'A
IEC 61000-4-4 (Edition 3.0) (2012-04)	Electrical Fast Transient/Burst immunity test on power line	Level-2/± 1 kV	Power port	PASS- Criterion 'A'
	Electrical Fast Transient/Burst immunity test on signal line	Level-2/± 1kV	Signal port	PASS- Criterion 'A'

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Applicable Standard	Applicable Test	Frequency range/ Class/ Test level	Applicable port	Results-Criterion
IEC 61000-4-5 (Edition 3.0) (2014-05)	Surge immunity test on power lines	CM: Level-2/±1kV DM:Level-2/±0.5kV	Power port	PASS-Criterion A’
IEC 61000-4-6 (Edition 4.0) (2013-10)	Conducted immunity test on power lines	150 kHz to 80 MHz Level-3/ 2Vrms	Power port & Signal port	PASS Criterion ‘A’
IEC 61000-4-8 (Edition 2.0) (2009-09	Power Frequency Magnetic Field immunity test	Level-2/ 3A/m	Enclosure	PASS-Criterion ‘A’
IEC 61000-4-11 (Edition 2.0) (2004-03)	Voltage dips and short Interruptions	0 % (dip) for 10 ms 0 % (dip) for 20 ms 70% (dip) for 500ms 0 %(Int) for 5 s	Power port	PASS-Criterion ‘B’

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GENERAL SAFETY INSTRUCTIONS

Review the following safety precautions to avoid bodily injury and/or damage to the product. These precautions must be observed during all phases of operation or service of this product. Failure to comply with these precautions, or with specific warnings elsewhere in this manual, violates safety standards of design, manufacture, and intended use of the product. Note that this product contains no user serviceable parts or spare parts.

Service should only be performed by qualified personnel. Disconnect all power before servicing.

TERMS AND SYMBOLS

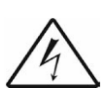
These terms may appear in this manual:

WARNING Indicates that a procedure or condition may cause bodily injury or death.

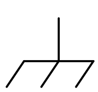
CAUTION Indicates that a procedure or condition could possibly cause damage to equipment or loss of data.

These symbols may appear on the product:

Attention and Warning - Important safety instructions, refer to manual

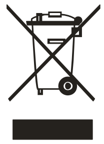


Warning, possibility of electric shock, refer to manual



Frame or chassis ground

Safety ground, required to be connected to local earth ground



Indicates that the product was manufactured after August 13, 2005. This mark is placed in accordance with *EN 50419, Marking of electrical and electronic equipment in accordance with Article 11(2) of Directive 2002/96/EC (WEEE)*. End-of-life product can be returned to AMETEK by obtaining an RMA number. Fees for take-back and recycling will apply if not prohibited by national law.

WARNINGS

Follow these precautions to avoid injury or damage to the product:

Apply local earth ground

The safety earth ground cable provided with this instrument meets the required regulatory and statutory safety standards as indicated by this product's declaration of conformity. The green/yellow safety cable must be applied between the safety ground on the rear of the unit and the local safety earth ground. This is required for safe operation of the equipment. Refer to the manual on how to apply the safety earth ground cable.

Use Proper PoE+ Source

This unit can be powered over Ethernet via PoE+ (IEEE 802.3at). When using PoE+ to power your unit, only use VTI recommended powered Ethernet switches, a list is available in this manual. Using a powered switch that is not on VTI's recommended list may not work.

Use Proper AUX Source

This unit can be optionally powered with an external DC source. When using the AUX DC Input to power your unit, VTI recommends using external supply (VTI# 56-0739-000R, this power adapter is shipped by default with EX1403A) or (VTI# 56-0739-120R, this power adapter is an optional accessory to be purchased separately). If desired, a different DC supply can be used if it meets the voltage, power, connector, and safety requirements. Use a power source that meets the same safety and CE requirements listed on the declaration of conformity for this product. Verify that the connector pin-out is the same as required for this product.

Avoid Electric Shock

To avoid electric shock or fire hazard, do not operate this product with the covers removed. Do not connect or disconnect any cable, probes, test leads, etc. while they are connected to a voltage source. Remove all power and unplug unit before performing any service. ***Service should only be performed by qualified personnel.***

Operating Conditions

To avoid injury, electric shock or fire hazard:

- Do not operate in wet or damp conditions.
- Do not operate in an explosive atmosphere.
- Operate or store only in specified temperature range.
- Provide proper clearance for product ventilation to prevent overheating.
- DO NOT operate if any damage to this product is suspected. Product should be inspected or serviced only by qualified personnel

Improper Use

The operator of this instrument is advised that if the equipment is used in a manner not specified in this manual, the protection provided by the equipment may be impaired.
Conformity is checked by inspection.

SECTION 1

INTRODUCTION

OVERVIEW

The EX1403A is a 16-channel high-performance strain gauge measurement instrument. Its combination of measurement performance and integrity, configuration flexibility, package density, and network connectivity make it the most powerful, yet easy-to-use, instrument of its kind. The EX1403A is a complete, self-contained strain measurement system that communicates over Ethernet. Unlike other data acquisition offerings in its class, the EX1403A offers a tightly integrated solution that frees the user from the complexity of marrying terminal blocks, signal conditioning cards, digitizer, excitation source, and chassis together.

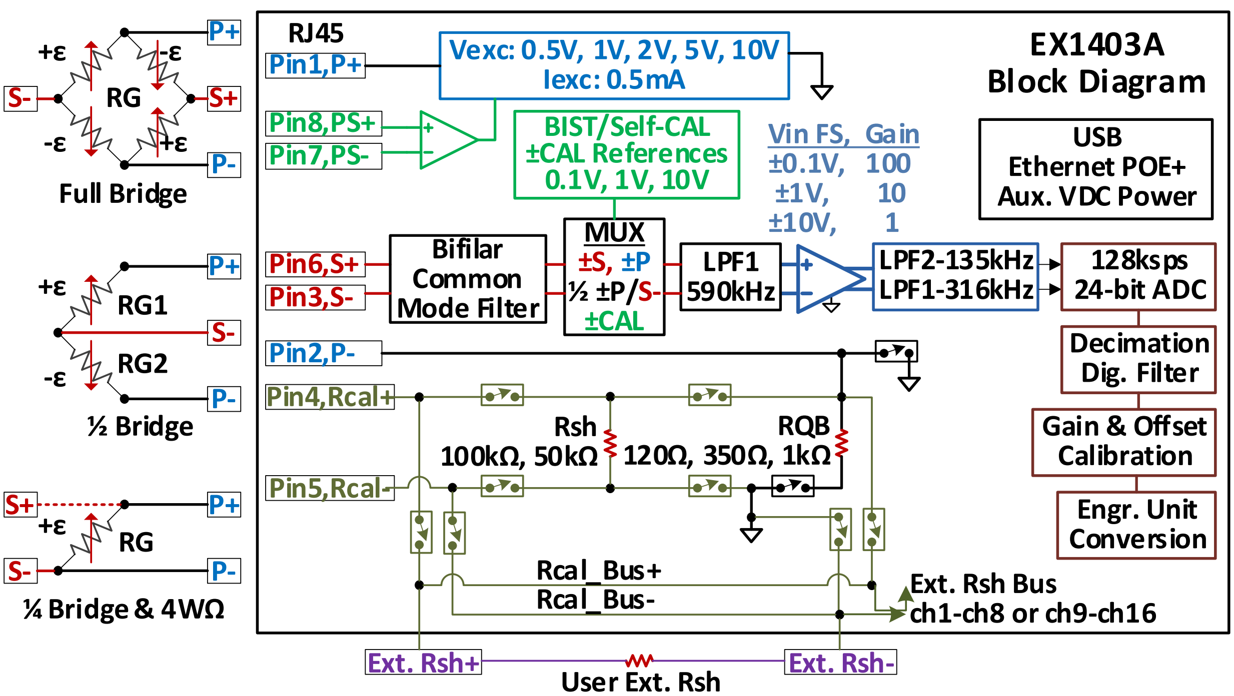


Figure 1-1:: EX1403A Functional Block Diagram

FEATURES

HIGH DENSITY SOLUTION

The EX1403A provides 16 channels of strain conditioning, bridge completion, and excitation in a single 1U rack-mount enclosure. Its density and integration simplify the task of assembling a test station. Most applications require only the simple connection of power, Ethernet communication, and input connections. Moreover, test consistency and reliability are greatly increased because its base configuration requires no accessory modules or other equipment to be connected or cabled together. The design of the EX1403A provides full configuration flexibility, with all bridge completion and excitation source configurations set programmatically. There is no need to manually reconfigure hardware to make measurement changes. The EX1403A can operate independently or, for large data acquisition applications, multiple instruments can be synchronized via IEEE 1588-2008 (PTP V2) and LXI Lan Event Messages, or via hardware TTL Triggers. This design allows for numerous units to be controlled by a single host computer scalable for Synchronized High-Speed and High-Channel Count.

In addition to base class LXI compliance, this instrument also provides extended capabilities like LXI Clock Synchronization, Event Messaging, and LXI Time Stamped Data, to support easy integration and synchronization of multiple devices.

DATA INTEGRITY

The design of the EX1403A placed paramount importance on maintaining data integrity under all measurement conditions. Each input channel is an independent measurement system, with discrete signal conditioning circuitry, and 24-bit ADC. Each channel is individually protected against shorts to ground, across the gage, or to another gage, as well as overvoltage. EX1403A provide superior high-frequency common mode noise rejection. Finally, an analog filter provides anti-alias protection for dynamic applications.

EXCITATION SOURCE

All input channels of EX1403A can provide bridge excitation, which is programmable on every channel, independently. The excitation can be of constant voltage type, or constant current type.

Constant Voltage Excitation: 0.5V, +1V, +2V, +5V, +10V with up to 35mA Current drive. (consult factory for custom excitation levels up to 10V)

Constant Current Excitation: 500µA (1mA for EX1403) with up to >10V Compliance voltage. (consult factory for excitation levels up to 5mA)

This Programming independence provides the flexibility of balanced or imbalanced excitation. Finally, remote sense lines on each input connector can be employed for improved half-bridge and full-bridge performance

PROGRAMMABLE BRIDGE CONFIGURATIONS

Complete bridge configuration support is selectable under program control on per channel basis. Options include full, half, quarter120, quarter350, quarter1000, quarter User bridges, as well as direct 2-wire or 4-wire resistance measurement of the gauge. Moreover, a high impedance voltage mode provides direct voltage measurements up to ±10 V.

SIMPLIFIED INSTALLATION, SETUP AND CONTROL

In addition to compliance to LXI base specifications, the EX1403A also implements the LXI Clock Synchronization, and LXI Event Messaging, Time Stamps and Event Logs. These features make the EX1403A instruments ideal for distributed measurements throughout a facility – reducing cabling and installation expense. The ability to connect directly to an Ethernet network using industry standard Ethernet cable and connections makes it easy for network administrators to oversee the installation. Using a PoE+ enabled Ethernet switch allows both power and measurement data on a single wire. *IVI Digitizer class* driver compliance simplifies installation and setup.

An onboard, web-accessible user interface allows you to instantly verify communications and instrument functionality, while IVI drivers provide a familiar application programming interface to further reduce integration and program development time. For comprehensive, programming-free data recording setup, management and viewing, use EX1403A instruments with one of VTI's full-featured, turnkey software solutions, such as EXLab.

CHANNEL INDEPENDENCE

Each of the EX1403A's 16 differential input channels is an independent signal conditioning path, complete with amplification This independence frees the user from the problem of channel-to-channel crosstalk that is pervasive in most multi-channel data acquisition systems. In the EX1403A, channels have no influence on each other, regardless of scanning speed or channel state.

SHUNT CALIBRATION

The traditional shunt calibration process is supported to ensure correct bridge performance. Each input channel provides a unique, precision 50 kΩ and 100 kΩ resistor that can be programmatically connected locally for quarter-bridge shunting or remotely for full- or half-bridge shunting. Moreover, an external resistor may be connected into each of two front panel connectors, one for each group of 8 input channels. Similarly, this front panel resistor may be programmatically connected locally (on instrument) or remotely (near strain gage).

TEDS TRANSDUCER SUPPORT

The EX1403A provides support to read TEDS-equipped sensors to allow direct input of bridge configuration parameters and input configuration management.

DIGITAL FILTER

The EX1403A allows the user to configure different types of digital filters. These digital filters are implemented inside the FPGA of the device, such that they perform consistently and without loading the host computer resources. Users can optimize the filter settings for aggressive filter performance or lower data latency time. In addition, users can customize the FIR filter performance by editing the coefficients of the filter. This provides ultimate flexibility in designing a filter to suit the application needs.

INPUT CONNECTORS

The EX1403A features a standard RJ-45 telecom connector for each input channel. Not only are these connectors reliable, but low-cost construction of custom length cables is also readily available. Reconfiguration or replacement of strain gage connections is as easy as connecting a telephone

SAMPLING RATE

The EX1403A is designed for sampling speeds up to 128 kSa/s per channel, regardless of the number of enabled channels.

DIGITAL I/O AND LIMITS

The EX1403A allows the user to define a unique set of programmable limits that are used for general purpose input channel monitoring. These limits are programmable on a per channel basis and are evaluated within the instrument with each completed scan. The output of limit evaluations is presented via front panel LEDs, digital I/O port, LAN events, and through the instrument driver.

The EX1403A features an 8-channel digital I/O port on the rear panel of the instrument. This port can be used as an arm/trigger source, for presentation of limit evaluation information, and as a general-purpose output device. As a general-purpose output device, each DIO channel can be independently programmed with regards to its output functionality and its static level to assume when enabled as an output. For expanded and more automated operation, each DIO channel can be independently linked to one or multiple limit conditions on one or more input channels. The digital I/O port is bank isolated to reduce ground loop noise issues when connected to external equipment.

TRIGGERING

The EX1403A supports a full function trigger model with a separate arm source and trigger source event structure. Trigger and arm source events can be independently programmed from a variety of sources including Immediate, Software, External TTL, Digital I/O, and LXI alarms.

MULTI-FUNCTION DISPLAY

The menu driven LCD display available on the rear side of the instrument provides instrument status, diagnostic reports, network details, and can also start, stop, and monitor measurement sequences that log data to an external USB disk without PC control.

USB DATA RECORDING

The EX1403A can export acquisition data at high speed to an external USB memory device, so that it can be used as a standalone data logger. This will also be useful to keep a redundant back up of data for high reliability applications, while streaming data over the Ethernet interface. It supports standard maximum partition size of EXT2, EXT3, EXT4, VFAT/FAT32, and MSDOSFS filesystems. The data can be stored in Hierarchical Data Format, HDF5 file format or comma-separated-value format (CSV). HDF5 being an open standard data file format, users can choose from a wide variety of tools to decompress, view, and export the time stamped measurement data. VTI Instruments also provides the *HDF5 Data Viewer and Converter* utility (available at https://www.powerandtest.com/ate-data-acq/platforms/lxi/ex1400-family/EX1403A/). This application can read the HDF5 format written by the EX1403A and allows users to view and export channel data to CSV, and to view and save metadata. For more information on HDF5 file formats and tools, visit the HDF Group's website: https://www.hdfgroup.org. The external USB memory device can also be used to store the user's desired instrument configuration.

SELF-TEST (BIST)

The EX1403A can perform internal diagnostics through self-test mechanism available via program control. This Built-In-Self-Test (BIST) checks for excitation and calibration reference voltages, calibration date, internal temperature, various status indicators, LEDs, and fan speed. This Built-In-Self-Test provides test system confidence and peace of mind by ensuring that the complete instrumentation measurement path is functional and delivers the most accurate result possible.

EX1403A SPECIFICATIONS

All specifications are typical (stated at the 95% confidence interval at 23°C ±5°C) unless otherwise stated. 60-minute warm-up minimum.

INPUT SPECIFICATIONS

Parameter	Specification
No. of Channels	16 channels
Input Connector	RJ45 connector (8 wire), pinout compatible with EX1629
Input Type	Differential Single-Ended: Input needs to be connected to GND externally
Input Range	Volts: ±10V, ±1V, ±0.1V Strain: ~±40kμε; Range=0.1V, Exc.=5V, GF=2 Ohms EX1403A: 20kΩ, 2kΩ, 200Ω; EX1403: 10kΩ, 1kΩ, 100Ω;
Accuracy (Tcal±3°C)	Volts: 0.1V Range: ± [(0.10%+140PPM/°C) Rdng + 9μV + 1μV/°C] 1V Range: ± [(0.06%+60PPM/°C) Rdng + 53μV + 5μV/°C] 10V Range: ± [(0.04%+10PPM/°C) Rdng + 442μV + 50μV/°C] Strain (Range=0.1V, Vexc=5V, GF=2, 100SPS): ¼ Bridge 120Ω: ± [(0.10%+140PPM/°C) Rdng + 15με +14με/°C] ½ & ¼ Bridge 350Ω & 1kΩ: ± [(0.10%+140PPM/°C) Rdng + 15με +6με/°C] Full Bridge: ± [(0.10%+140PPM/°C) Rdng + 2με +0.5με/°C] Note: excluding errors from lead wire resistance. Excitation to be applied to gage for >30min before zero balancing bridge (measure $V_{unstrained}$) to allow for thermal stabilization of the gage and completion resistors. 2/4Wire-Ohms & RTD(Ω): EX1403 (0% to 90%FS) & EX1403A (0% to 100%FS) ± [(0.05%+140PPM/°C) Rdng +0.01% Rng]
Maximum Input, no damage	±12V. ESD protected to ±10kV
Input Ground Isolation	No channel to channel Ground Isolation
Input Coupling	DC
Input Impedance	>100 MΩ each input to ground
Slew Rate: 10% to 90% FS	30 V/μs Typical
Common Mode Rejection	-120dB Typical, <100 Hz -100dB Typical, 100Hz – 1kHz -90dB Typical, 1kHz – 10kHz
Channel-to-Channel Crosstalk	-120dB Typical, <1kHz Overdriving 1 channel does not affect performance of other channels
Bridge Zero Balance	Software nulling Excitation to be applied to strain gage for >30min before zero balancing bridge to ensure gage & completion resistors have thermally stabilized
Bridge Types	Full, Half (½), Quarter (¼)
Bridge Completion	¼ Bridge Completion Software Selectable: OFF, 120Ω, 350Ω, 1000Ω 350Ω & 1kΩ: SMD Thin Film, 0.1% ±13 ppm/°C 120Ω: SMD Thin Film, 0.1% ±60 ppm/°C Bridge completion resistance measured within ±0.05% and stored in memory for use during internal shunt calibration ½ Bridge Completion: 10k-10k thin film resistor network, 0.1% ±25 ppm/°C

NOISE SPECIFICATIONS

Voltage Noise

The figure below shows the typical Voltage RMS noise vs. sample rate with Range set to 0.1V, 1V and 10V.

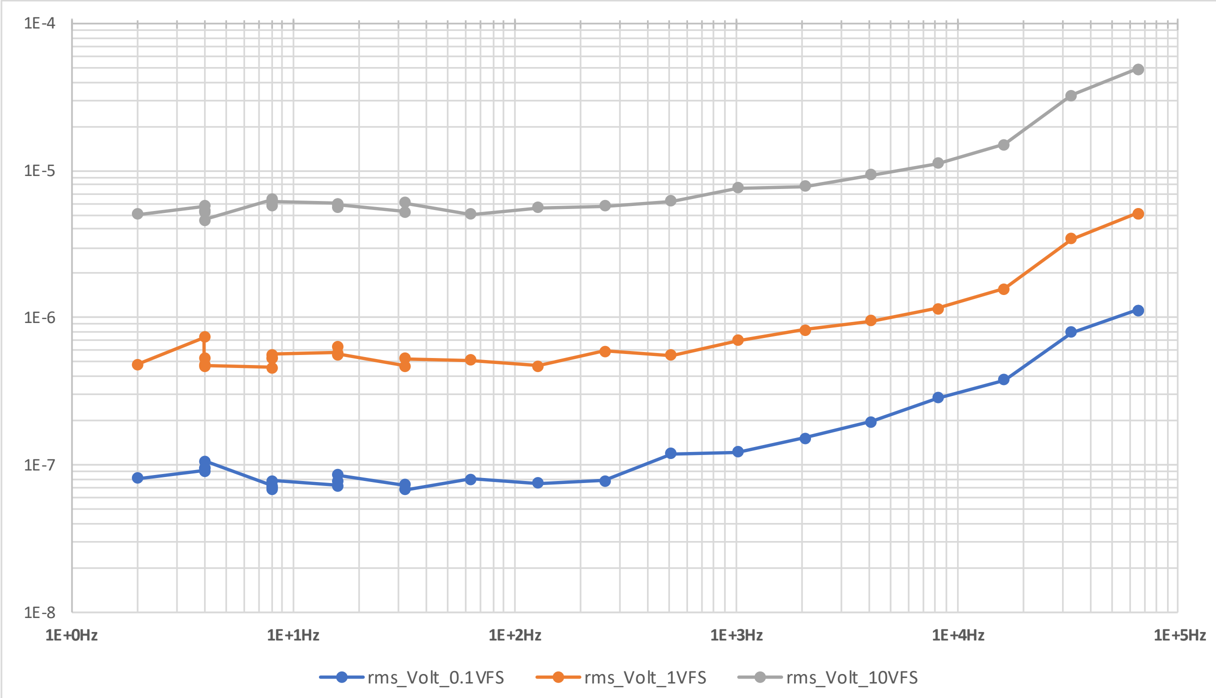


Figure 1-2: Typical RMS Noise (Volts): Function=Voltage, Range=0.1V, 1V, & 10V

The figure below shows the typical Voltage peak-to-peak noise vs. sample rate with Range set to 0.1V, 1V and 10V.

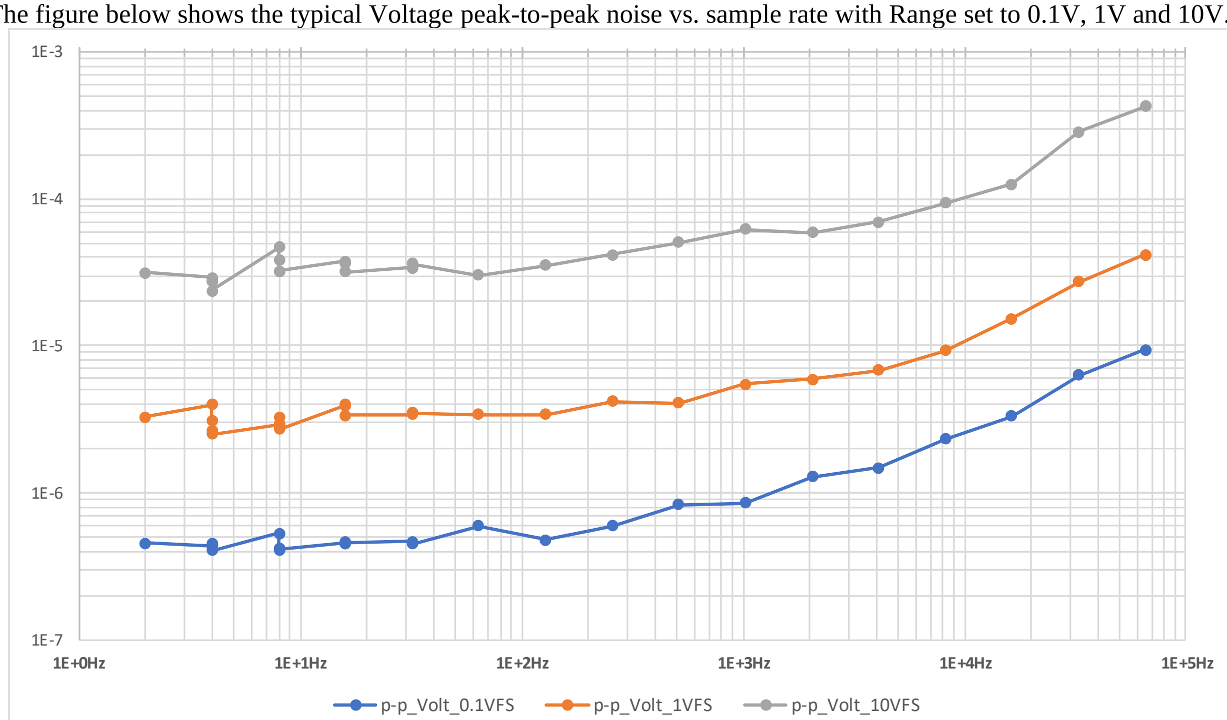


Figure 1-3: Typical peak-to-peak Noise (Volts): Function=Voltage, Range=0.1V, 1V, & 10V

Strain Noise

The figure below shows the typical strain (ε) RMS noise vs. sample rate with Range set to 0.1V for a 350Ω quarter-bridge connected to the input. The multiple noise points for low sample rates represent the noise from 2 to 20 minutes.

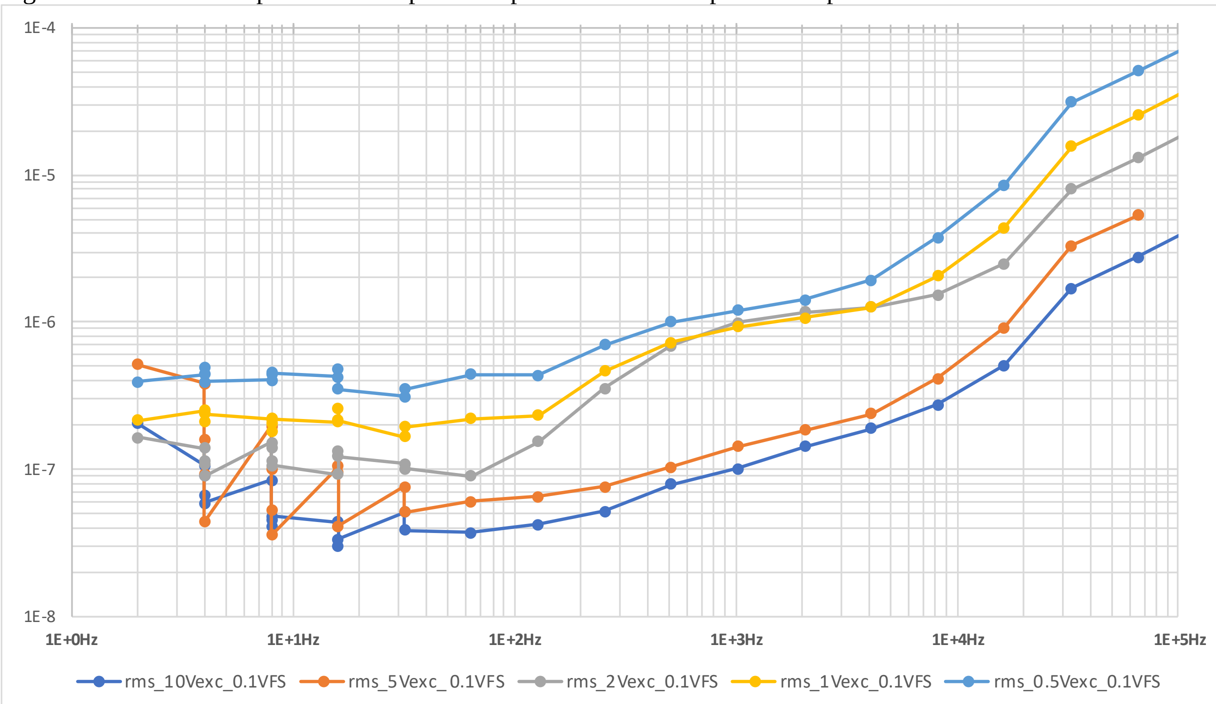


Figure 1-4: Typical RMS Noise (ε), Function=Strain, Range=0.1V

The figure below shows the typical strain (ε) peak-to-peak noise vs. sample rate with Range set to 0.1V for a 350Ω quarter-bridge. Noise is similar for 10V & 5V excitations.

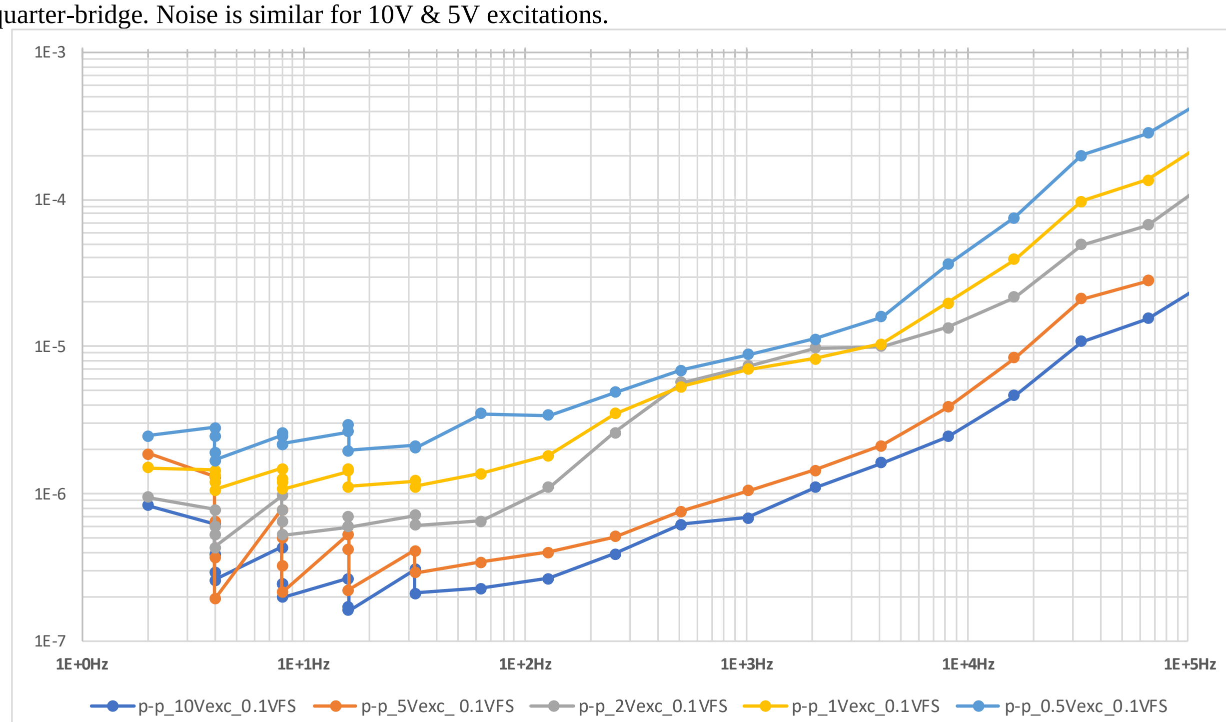


Figure 1-5: Typical peak-to-peak Noise (ε), Function= Strain, Range=0.1V

The figure below shows the typical strain (ε) RMS noise vs. sample rate with Ranges set to 0.1V, 1V, & 10V for a 350Ω quarter-bridge. Noise is the same for 0.1V & 1V ranges for long duration tests (>5 minutes)

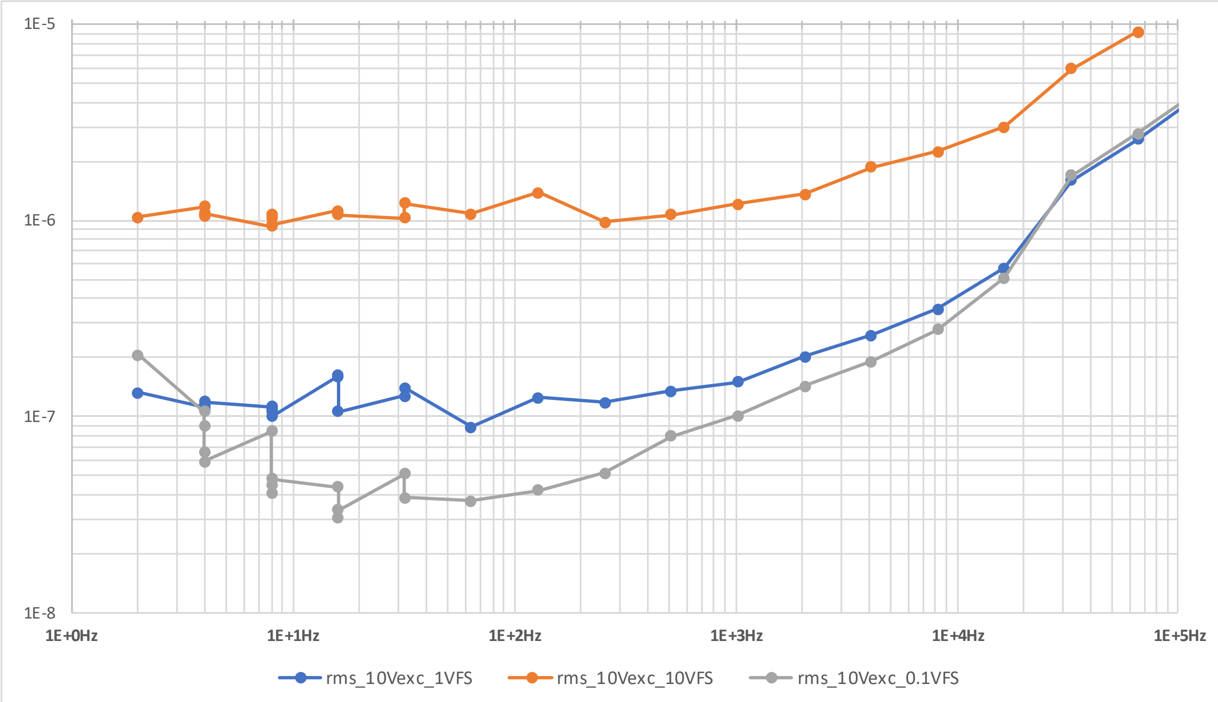


Figure 1-6: Typical RMS Noise (ε): Function=Strain, Range=0.1V, 1V, & 10V

The figure below shows the typical strain (ε) peak-to-peak noise vs. sample rate with Ranges set to 0.1V, 1V, & 10V for a 350Ω quarter-bridge. Noise is lower for the 0.1V range for short duration tests (<5 minutes)

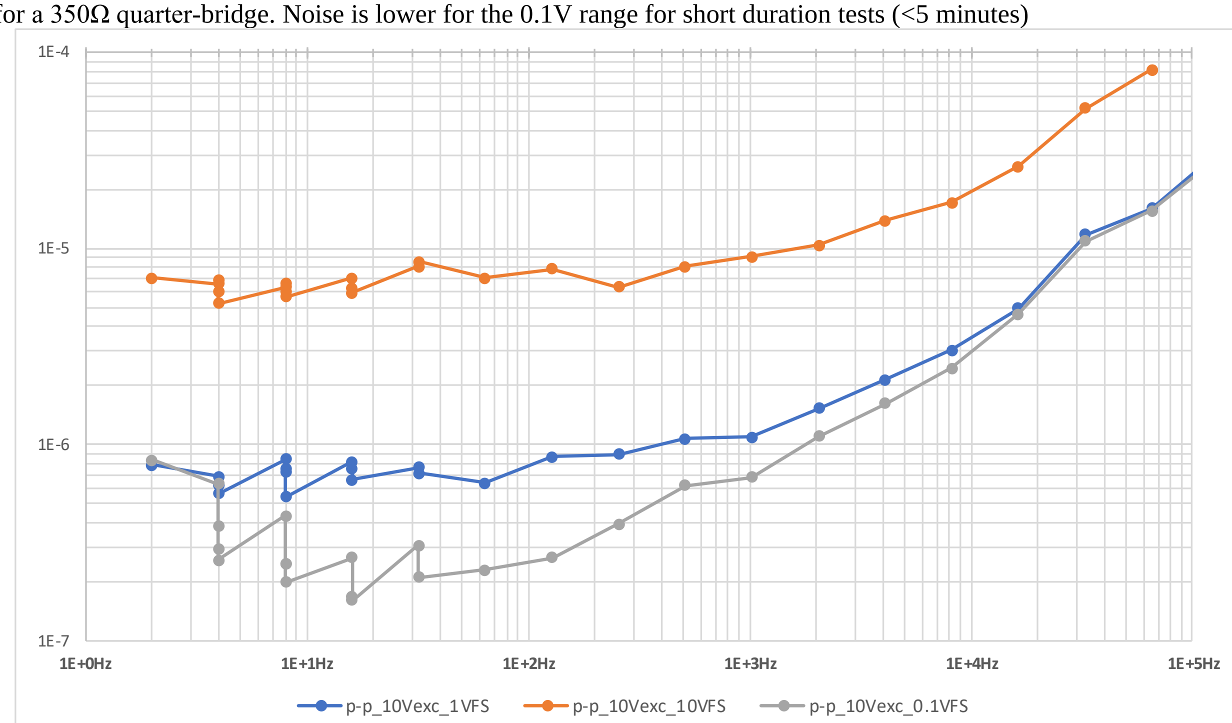


Figure 1-7: Typical peak-to-peak Noise (ε): Function=Strain, Range=0.1V, 1V, & 10V

Low frequency noise is also referred as offset or zero drift and it is due to temperature changing over time. Zero drift for full bridge is dependent mainly on the performance of the signal conditioning electronics (amplifier & ADC) and it is like the voltage noise. Zero drift for quarter bridge is due to the change in resistance of the quarter and half bridge completion resistors over temperature over time. Temperature changes slowly Drift can be reduced by maintaining the EX1403A at a constant temperature during the duration of the test. Tests with longer duration can exhibit more drift because

The fan can reduce temperature inside the unit at a rate of up to ~ 2°C/min depending on the fan speed. Temperature inside the unit can increase at ~1°C/min when the fan is turned off and ambient temperature is stable at 23°C (74°F). It takes ~1 hour for internal temperature to stabilize after initial power ON with the fan OFF.

EXCITATION SPECIFICATIONS

Channel-to-Channel Isolation	All channels share the same ground Each channel provides separate excitation circuitry
Voltage Excitation	Software Selectable per channel: +0.5V, +1V, +2V, +5V, +10V with Sense lines Measured with ±0.05% accuracy and saved in memory to convert voltage to strain units ±10 ppm/°C for +5V & +10V; ±30 ppm/°C for +0.5V, +1V & +2V; ±50ppm/year Current Limit: 35mA (Min. Rload = Vexc/0.035A) Load regulation: <0.05% for load change < 32mA Crosstalk: <0.03% effect on other channels from load changes Noise: 20 µVRMS Typical, 50kHz bandwidth Excitation Sensing: Max. Voltage at ±P: 11V Voltage Excitation Monitoring: every ~1 second when all 16 channels enabled for dynamic excitation
Current Excitation	EX1403: 1mA EX1403A: 0.46mA Measured with ±0.05% accuracy and saved in memory to convert voltage to Ohms (Ω) units Stability: ±230 ppm/°C ±50ppm/year Load regulation: <0.01% for Load change 0V to 5V Crosstalk: <0.01% effect on other channels from voltage changes Compliance Voltage: >4.8V; Output Impedance: >10MΩ, DC to 20kHz Noise: <3nA RMS 10Hz to 40kHz Custom models can be made with other current excitation levels
Excitation Protection	Protected if driven by external voltage source: -0.3V to +12V Crosstalk: A short does not affect Excitation accuracy in other channels ±10kV ESD protection

Note: At 10V excitation, minimum 350 Ohm Gauge resistor shall be used.

ADC SPECIFICATIONS

There is one 24-bit delta-sigma analog-to-digital converter for each channel. The ADC runs at a fixed sampling rate so there is no need to change the corner of the analog anti-aliasing filter. The table below shows the available ADC sample/data rates:

Oversampling Ratio (F_{MOD} / F_{DATA})		**ADC Oversampling Clock (F_{MOD})**	**PLL Fclock**
64	**128**		
ADC Data Rate F_{DATA} (SPS)			
39,062.5	19,531.25	2,500,000 Hz	10,000,000 Hz
65,536	32,768	4,194,304 Hz	16,777,216 Hz
78,125	39,063	5,000,000 Hz	20,000,000 Hz
100,000	50,000	6,400,000 Hz	25,600,000 Hz
102,400	51,200	6,553,600 Hz	26,214,400 Hz
128,000	64,000	8,192,000 Hz	32,768,000 Hz

Parameter	Specification
ADC	24-bit ADS1278 (∑∆)
ADC Data Rate (SPS) (f_{DATA})	Programmable up to 128kSPS with filtered Decimation from 128k, 102.4k, 100k, 78.125k, 65.536k, 64k, 51.2k, 50k, 39.0625k, 32.768k & 19.53125k SPS Additional up to 65536 unfiltered (blind) decimation Accuracy: ±100PPM
ADC Digital Filter Passband (±0.05% ripple)	0.417 * f_{DATA}
ADC -3dB Bandwidth	0.424 * f_{DATA}
Group Delay	39 / f_{DATA}
Settling Time (Latency)	78 f_{DATA}

EX1403A supports decimated sample rates in addition to the base clock frequencies listed in the above table.

Programmable Digital Filters	Specification
None (No Filter)	Raw data
High Performance (FIR)	1 to 16 number of /2 stages (Selectable & Customizable)
Low Latency (CIC)	/4 to /8192 (Selectable)
Medium Latency (CIC+CFIR)	Low latency CIC filter, followed by /4 FIR Filter (Customizable)
Post Filter Blind Divider	1 - 65536 (selectable)

ADC SYNCHRONIZATION AND TRIGGERING

The ADC can be synchronized to an external clock signal or to an IEEE 1588 PTP grand master clock via Ethernet. The unit can be triggered by an external trigger input signal or by an LXI LAN event. The unit can also generate LXI LAN events or issue a trigger output signal. The trigger SMB connector can be configured as input or output.

Trigger Input/Output Specifications

Parameter	Specification
Trigger Input	Maximum Input Voltage: -0.5V to 5V, ESD protected VIL: < 0.5V; VIH: > 2.5V
Trigger Input Impedance	Signal is pulled high by a 4.7k Ohm resistor
Minimum Trigger Input Pulse Width Detection	1 µs
Trigger Output Swing	0V to 5V
Output Pulse Width for trigger event	1 µs
Output Drive	Can drive 50 Ohm coax. Source series termination for 50 Ohms

Clock Input/output Specifications

Parameter	Specification
Output Swing	0V to 3V
Duty Cycle	40% to 60%
Frequency	10 MHz phase locked to the ADC sample rate
Enable/Disable	Software control

NETWORK & DATA INTERFACE

Parameter	Specification
Speeds	10BASE-T/100BASE-T/1000BASE-T with auto-negotiation
Connector	RJ45

USB 2.0

This port is used to store data to an external memory device and not for control and/or data streaming to a host computer.

Parameter	Specification
Speeds	USB 2.0 High Speed (480Mbps)
Connector	USB type A
File System Supported	EXT2, EXT3, EXT4, VFAT/FAT32, and MSDOSFS
File Format Supported	HDF5 and CSV

TRANSDUCER ELECTRONIC DATA SHEET (TEDS)

The unit can read and write 1 TEDS memory device per sensor input connector using industry standard MicroLAN (MLAN) protocol through the input RJ45 connectors pins 4 & 5

Parameter	Specification
Protocol	MicroLAN
Baud Rate	9600 Baud
Electrical Specifications	5V
Driver type	1-Wire Maxim Integrated DS2480B+
Capacitance Loading (1-Wire input)	< 2000pF

POWER

The unit can be powered from either POE+ (25.5W) or an auxiliary DC input.

Parameter	Specification
POE+	IEEE 802.3at
Auxiliary Power	+12VDC to +50VDC The auxiliary power source supplies the power even if PoE power is already present. The unit may reboot if auxiliary power is applied after it had already been powered from a POE+ compliant PSE
Max. Input Power Requirements	25 Watt (includes 5W maximum to bridge transducer)
Power Input Over Voltage Protection	Reverse polarity protection
Power Control	The unit can identify if the unit is operating from a POE+ type 2 PSE or from AUX power, and whether power is good.
Ripple to Meet All Specs	<1% pk-pk

ENVIRONMENTAL

Parameter	Specification
Temperature	Operating Temperature: 0°C to +50°C Storage Temperature: -40°C to +71°C MIL-PRF-28800 Class 3
Relative Humidity, non-condensing	Operating: 10%-90% Storage: 5% to 95% MIL-PRF-28800 Class 3
Vibration & Shock	MIL-PRF-28800F Class 3
Altitude	4600M, MIL-PRF-28800 Class 3
CE Compliance	YES
EMC Directive	EMC EN 61326 Class A, Criteria A.
Service Life	> 10 Years
ROHS	ROHS2 Complaint
MTBF	200k Operational Hours

CONNECTORS

	QTY	Description	Part No.
Auxiliary Power	1	4-pin DIN Receptacle mates to CUI PDP-40 Plug	CUI PD-40S
Bridge /Analog Input	16	RJ-45	RJHSE-5481
Ethernet	1	RJ-45 CONN MAGJACK 1PORT 1000 BASE-T	0826-1X1T-GH-F
USB Type A	1	Receptacle USB Type A 2.0 4 Position	292303-1
Trigger & Clock	1	SMB	131-3701-301
Digital IO	1	CONN, DSUB, 9 PIN, FEMALE, RT, 0.318	TE-1734354-2

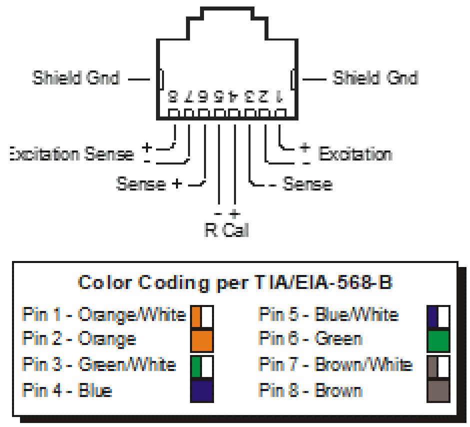
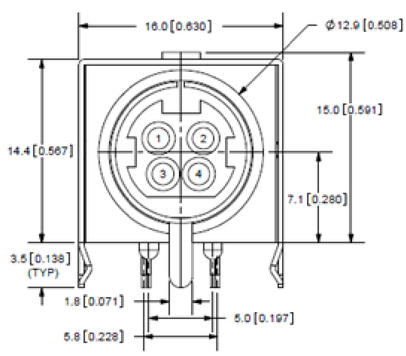


Figure 1-1: RJ-45 Transducer Input Connector Pin Assignment



DIN PLUG	POLARITY
P1	Vo
P2	Vo
P3	RTN
P4	RTN
SHELL	GND

Figure 1-2:: Power Connector Receptacle & Plug

Pin	Function
1	DIO Channel 0
2	DIO Channel 1
3	DIO Channel 2
4	DIO Channel 3
5	DIO Channel 4
6	DIO Channel 5
7	DIO Channel 6
8	DIO Channel 7
9	GND

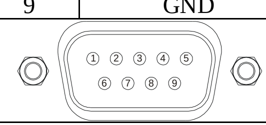


Figure 1-3: DIGITAL I/O DB-9 CONNECTOR

PHYSICAL SPECIFICATIONS

Parameter	Specification
Dimensions	9.81” x 9.22” x 2.27”, 1U, half-rack
Weight	3 kg
Material	Steel
Color	Powder Coating Black Texture Semi-Gloss Cardinal C241-BK01

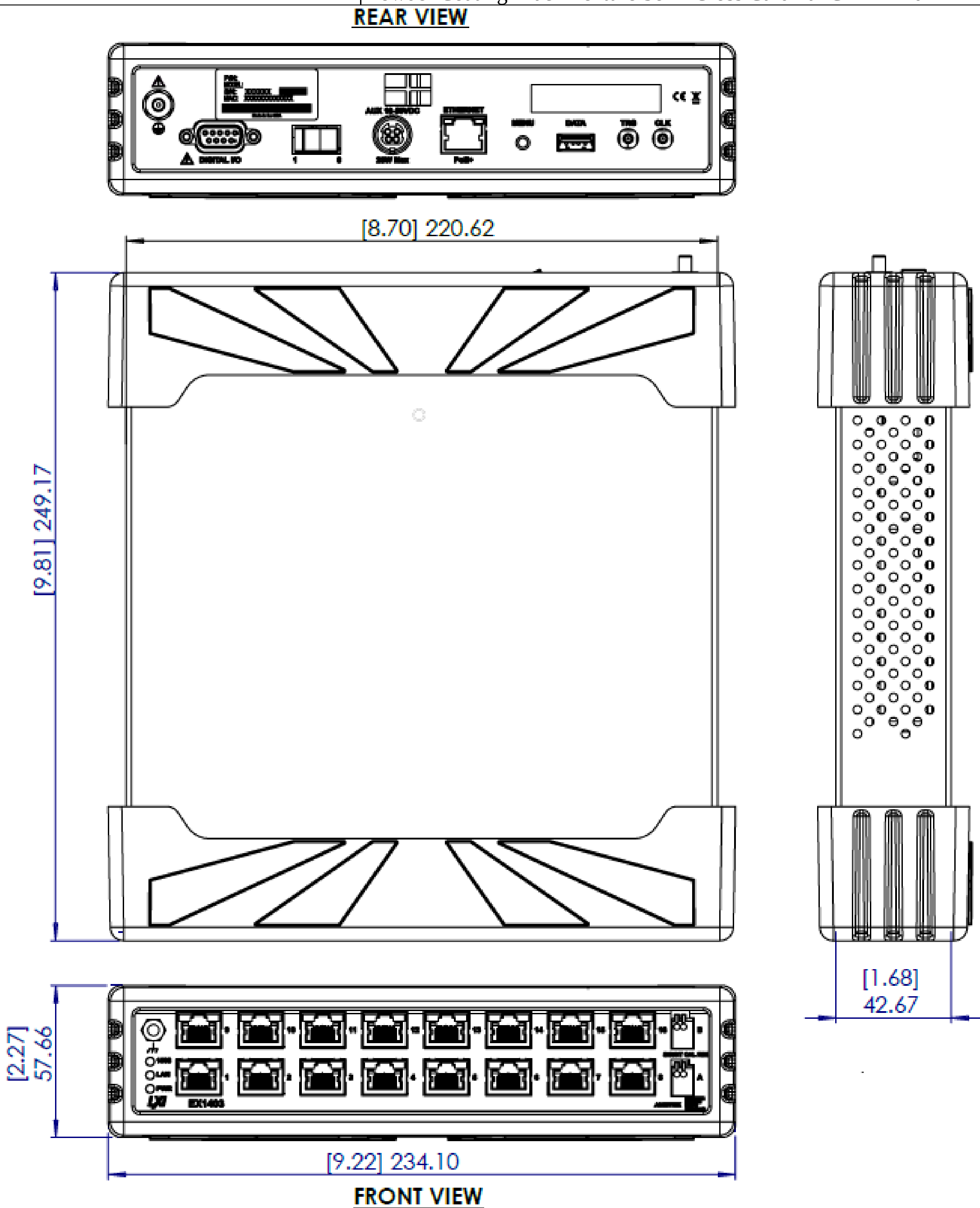


Figure 1-4:: EX1403A Dimensions [inch] mm

EX14XX-RK001 RACK MOUNT KIT PART # 70-0626-900R

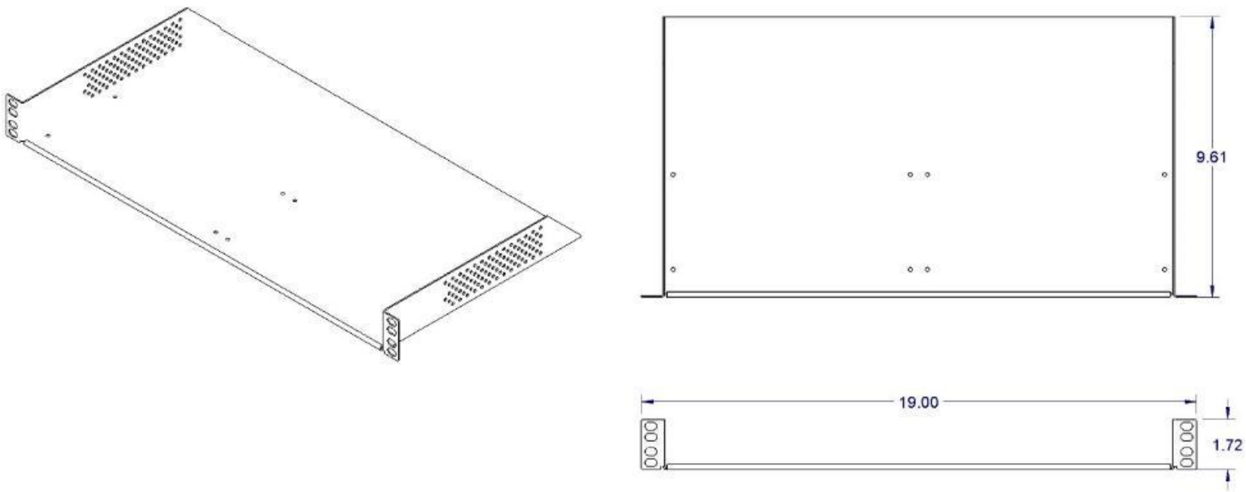


Figure 1-5: EX14XX-RK001RACK MOUNT KIT (inches)

BRIDGE CONFIGURATIONS

FULL BRIDGE

The figure below illustrates how to connect four strain gages in basic full-bridge bending configuration. To maximizing measurement performance, the remote excitation sense lines should ideally be used on the excitation source, connected at the same point that the ±Excitation lines are connected to the bridge. The shunt calibration lines (Pins 4 and 5), however, are only necessary if that functionality is required. Note that the gages in tension are connected from Pin 1 to Pin 6 and from Pin 2 to Pin 3 and the gages in compression are connected from Pin 2 to Pin 6 and from Pin 1 to Pin 3.

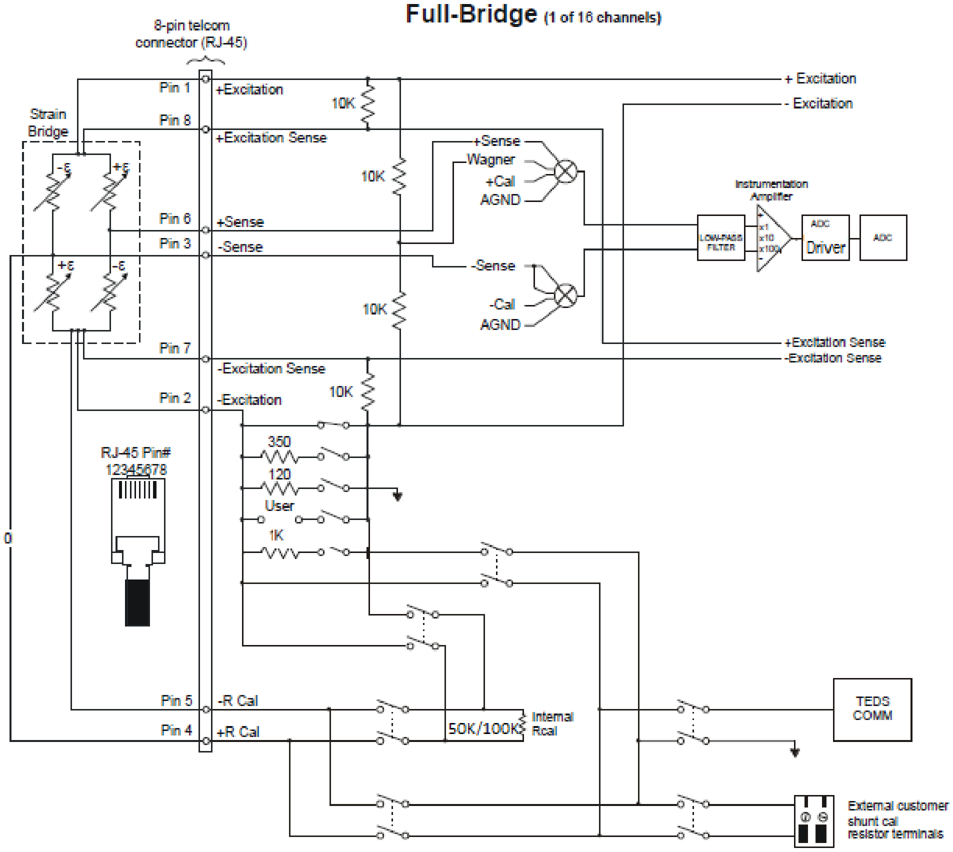


Figure 1-6: Transducer Connection: Full Bridge

HALF- BRIDGE

The figure below illustrates how to connect two strain gages in basic half-bridge bending configuration. To maximize measurement performance, the remote excitation sense lines should ideally be used on the excitation source, connected at the same point that the ±Excitation lines are connected to the bridge. The shunt calibration lines (Pins 4 and 5), however, are only necessary if that functionality is required. Note that the gage in tension is connected from Pin 1 to Pin 3 and the gage in compression is connected from Pin 2 to Pin 3. Furthermore, it is critical to understand how the EX1403A defines its measurement in this configuration.

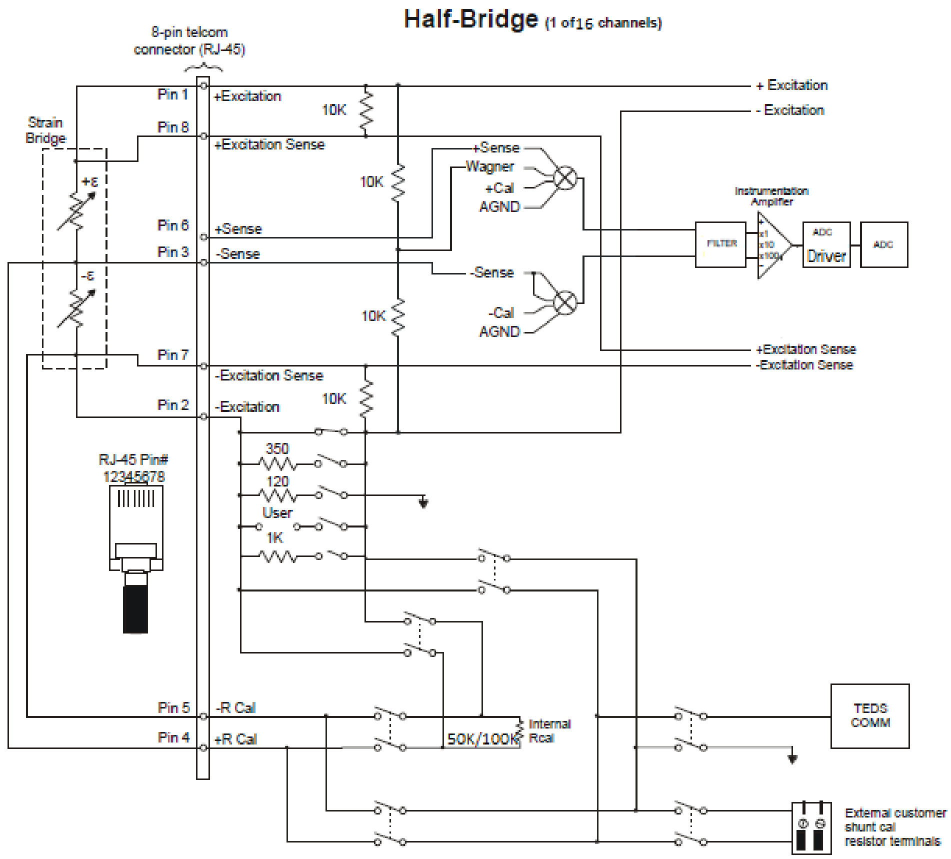


Figure 1-7: Transducer Connection: half Bridge

QUARTER- BRIDGE

The figure below illustrates how to connect a single strain gage in quarter-bridge configuration. To maximize measurement performance, the –Sense line should ideally be connected at the gage, instead of locally at the EX1403A input connector. Moreover, the wire length and gauge of the connections to Pins 1 and 2 should be matched. Fortunately, this is typically guaranteed by routing both lines as part of the same cable. For this configuration, the ±Excitation Sense lines are not used and must be left open, as opposed to being grounded or tied together. Whether the gage will be in tension or compression, the connection is the same.

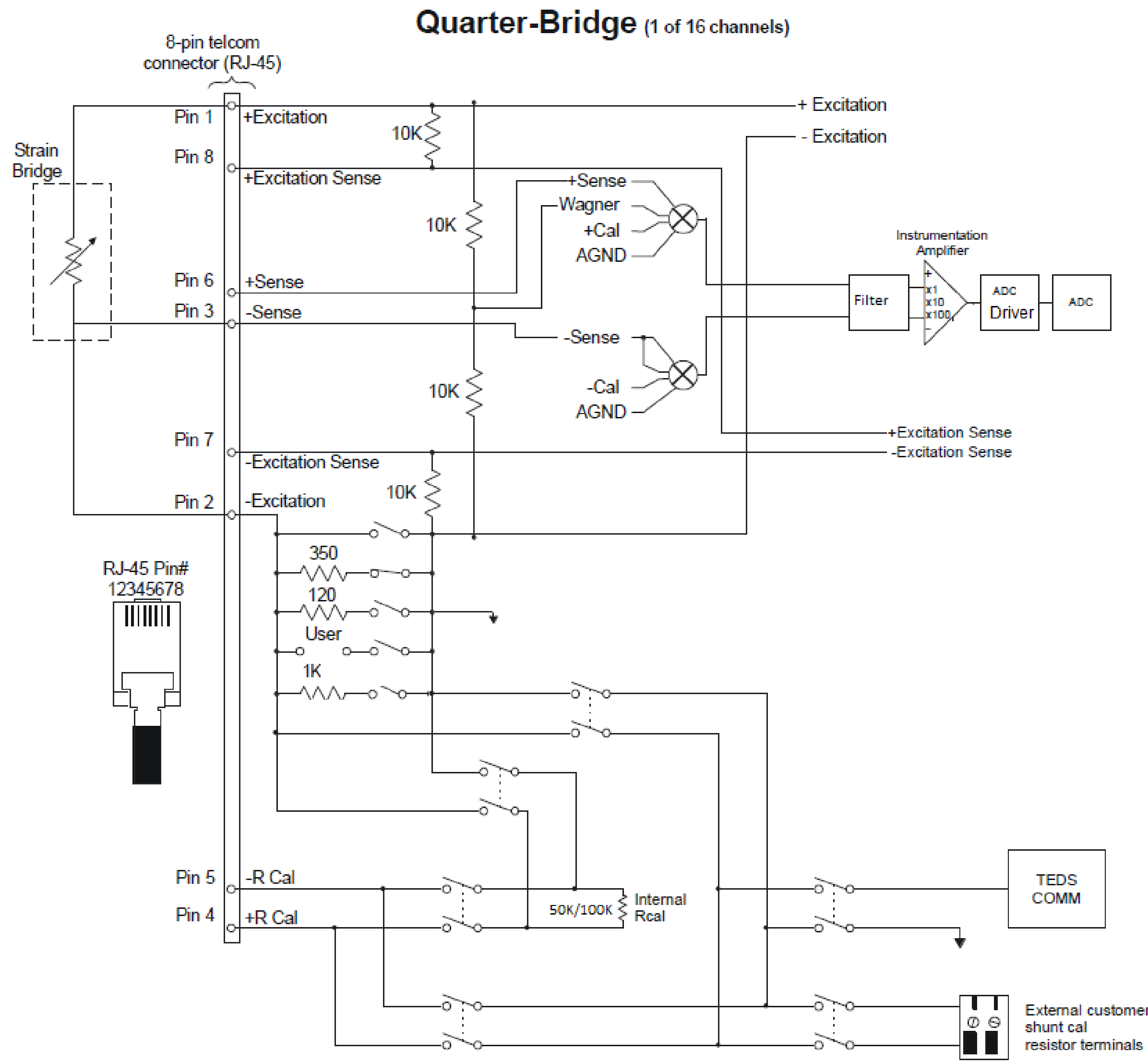


Figure 1-8: Transducer Connection QUARTER BRIDGE with 350 ohm completion

VOLTAGE MEASUREMENT

The EX1403A main input channels can also be used for general voltage measurement. For this application, the channel is effectively configured for Full-Bridge measurements (i.e., no completion resistor or “back-half” of the bridge is enabled). The signal to be measured should be connected to the +Sense and –Sense lines. For fully differential inputs, the configuration in Figure 1-9: VOLTAGE MEASUREMENT CONFIGURATION (DIFFERENTIAL INPUT) should be used. For situations that require a single-ended connection (i.e. one side grounded), the ground from the source is connected to the ground of the EX1403A.

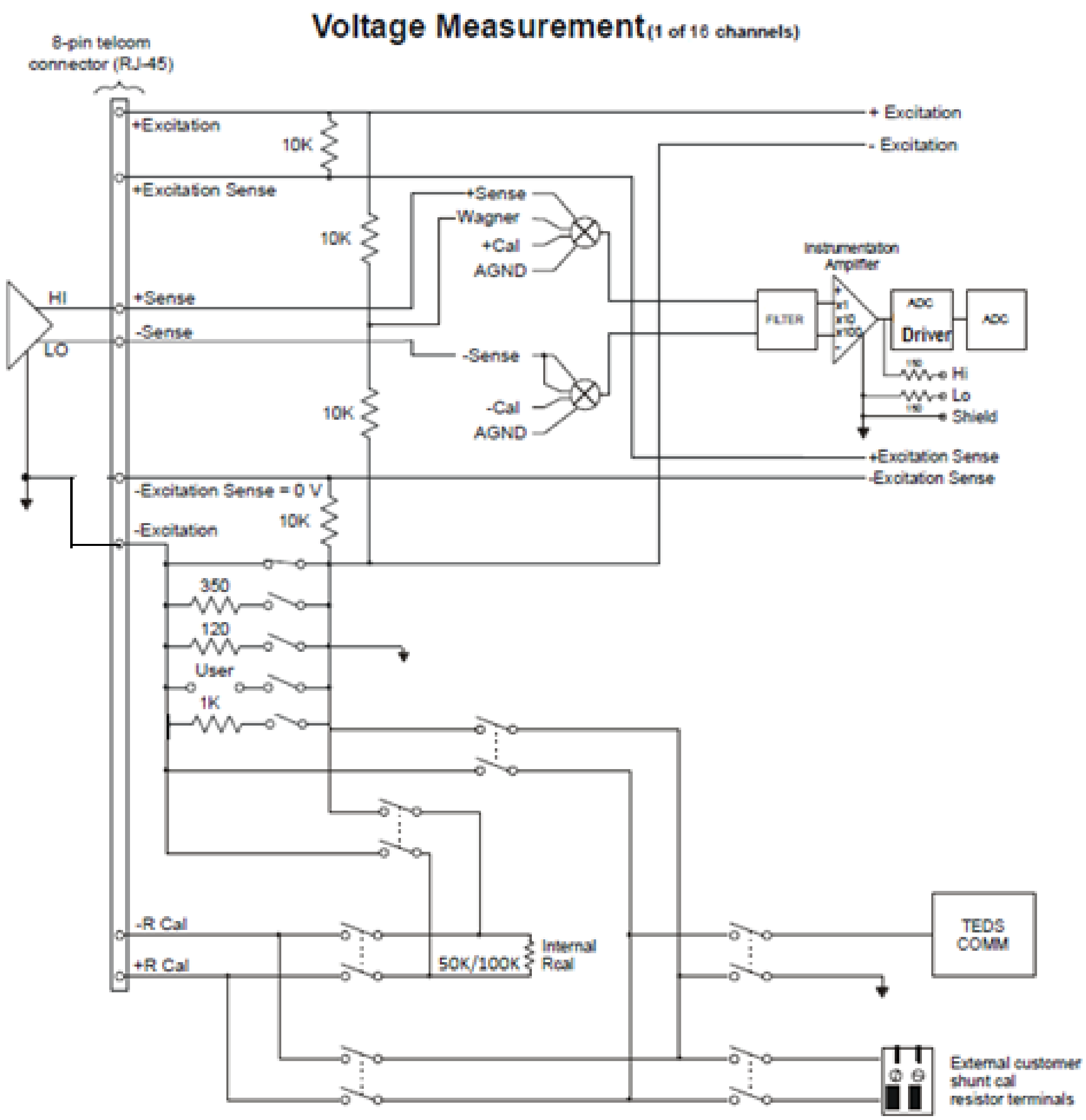


Figure 1-9: VOLTAGE MEASUREMENT CONFIGURATION (DIFFERENTIAL INPUT)

2- Wire Ohms

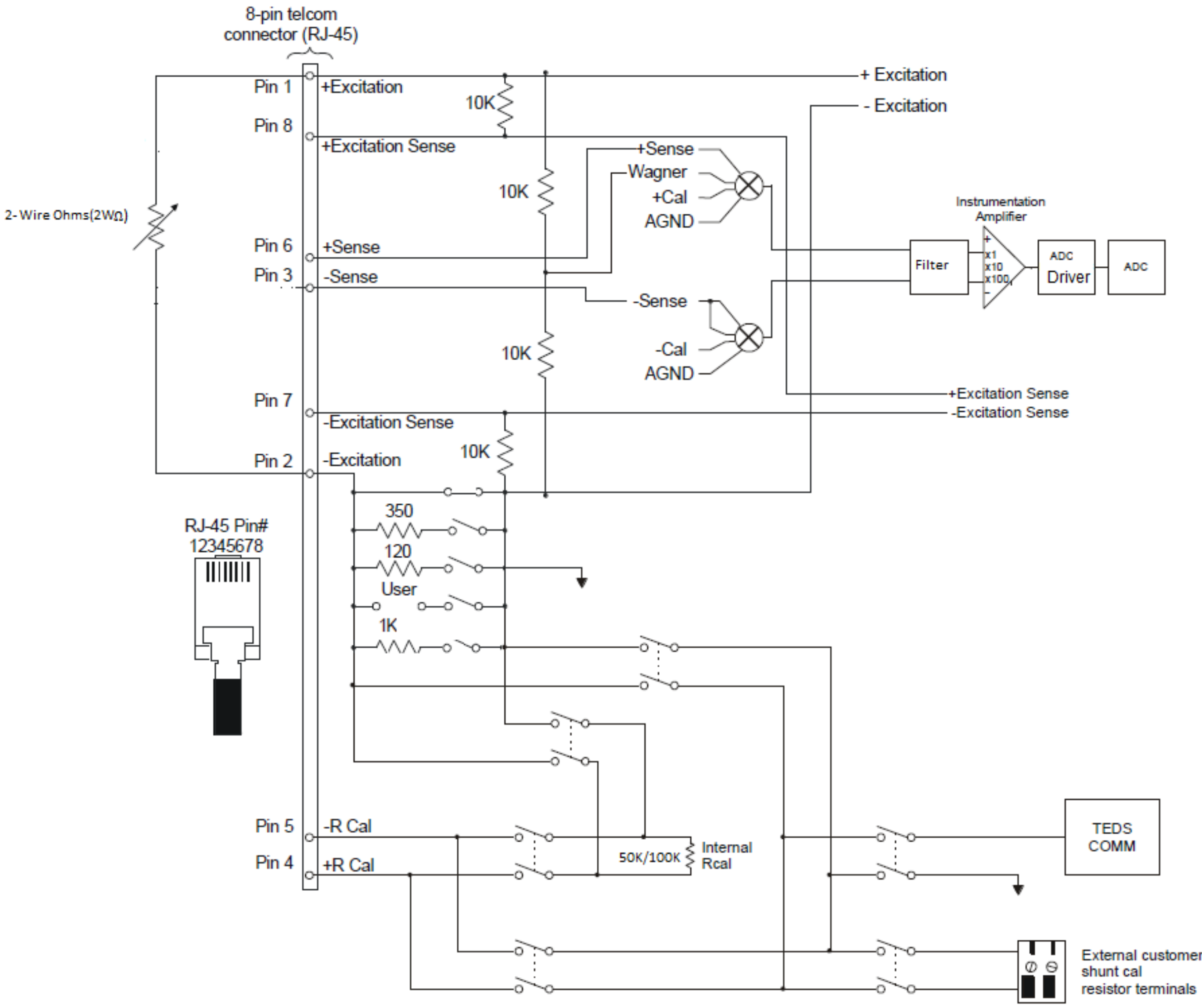


Figure 1-10: Transducer Connection: 2-Wire Ohms (2WΩ)

4- Wire Ohms

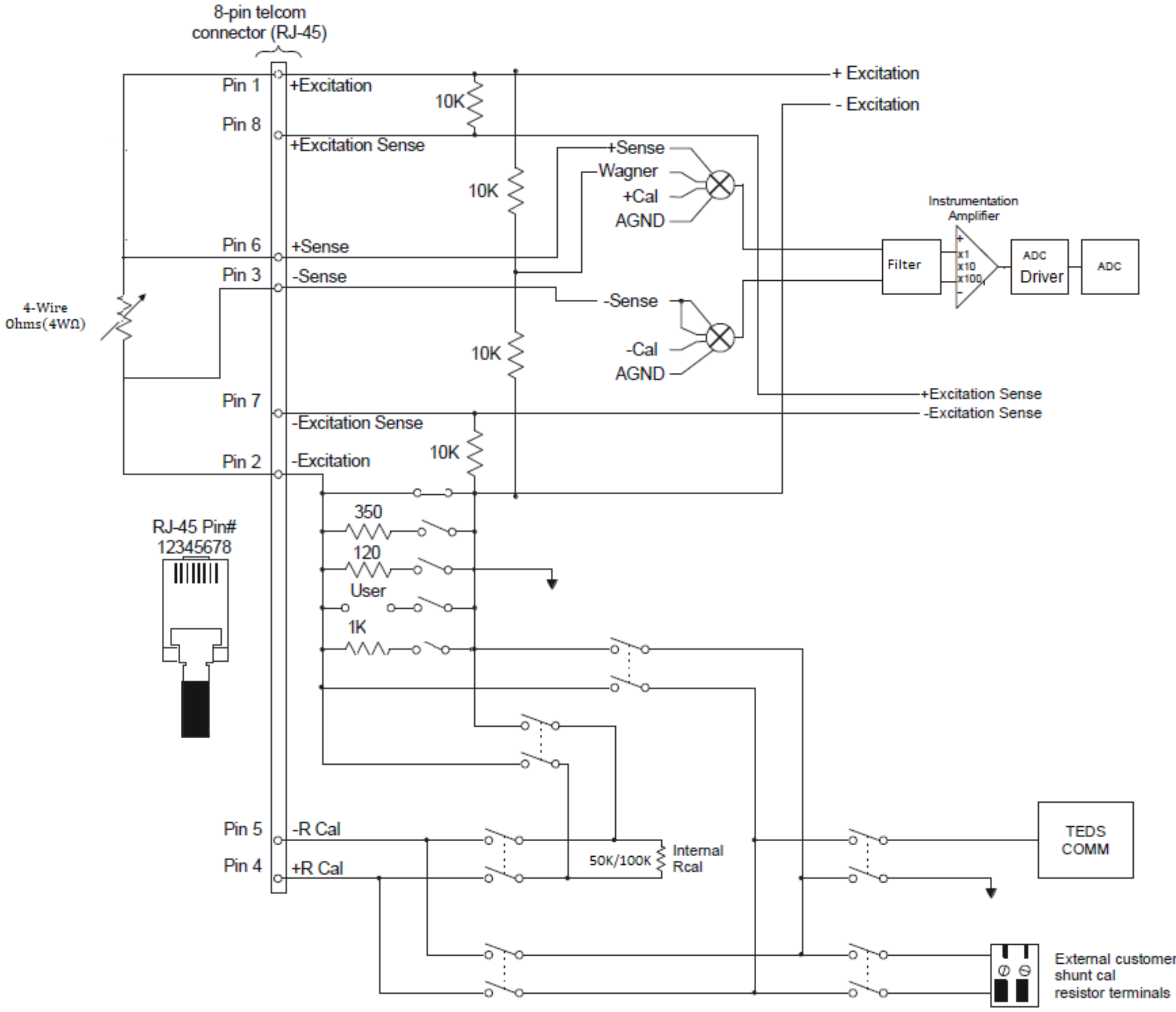


Figure 1-11: Transducer Connection: 4-Wire Ohms (4WΩ)

TEDS TRANSDUCER INTERFACE

The EX1403A supports reading and writing to Transducer Electronic Data Sheets (TEDS) devices that implement the IEEE 1451.4 standard. Each channel (1 through 16) functions as a 1-Wire bus master, although only one channel can be active at a time, reading, or writing. Only one TEDS device per channel is supported.
The software interface to support TEDS devices is a general-purpose API that will work with any 1-Wire TEDS device, implementing the MicroLAN (MLAN) protocol.

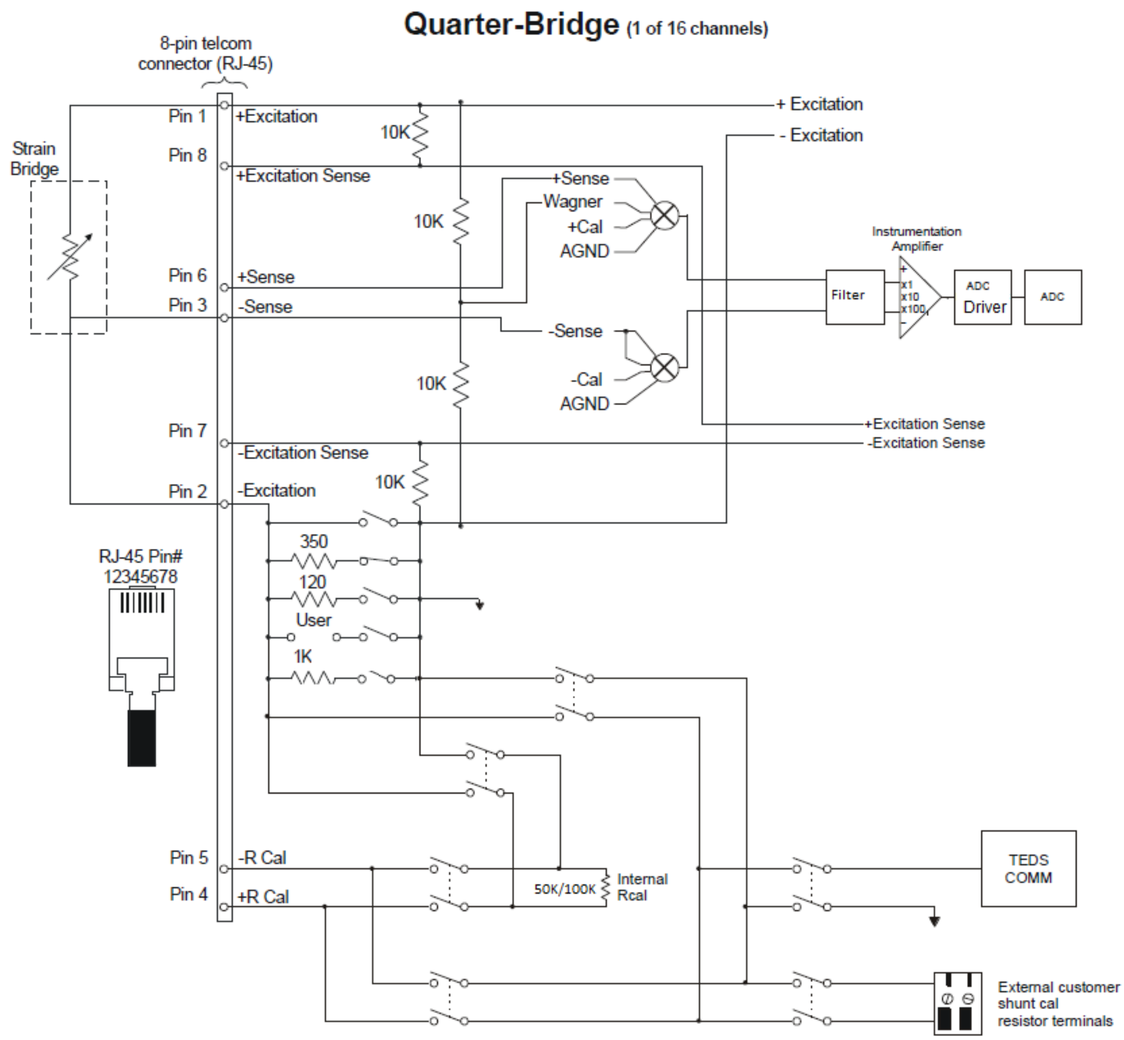


Figure 1-12: teds interface

NOTE:

TEDS memory device should be connected to the EX1403A as shown below (same connection as EX1629):
DS2430A pin 1 (GND) to EX1403A RJ-45 Pin 4 (RCAL+ / TEDS+)
DS2430A pin 2 (DATA) to EX1403A RJ-45 Pin 5 (RCAL- / TEDS-)

TEDS memory device should be connected to the EX1403 as shown below (reverse polarity than EX1629):
DS2430A pin 1 (GND) to EX1403 RJ-45 Pin 5 (RCAL- / TEDS-)
DS2430A pin 2 (DATA) to EX1403 RJ-45 Pin 4 (RCAL+ / TEDS+)

STRAIN SHUNT CALIBRATION

The EX1403A features an extremely capable and fully programmable shunt calibration architecture to ensure correct bridge performance. The calibration modes are supported in local and remote connections. The figure below shows the switching scheme implemented in the EX1403A for shunt calibration.

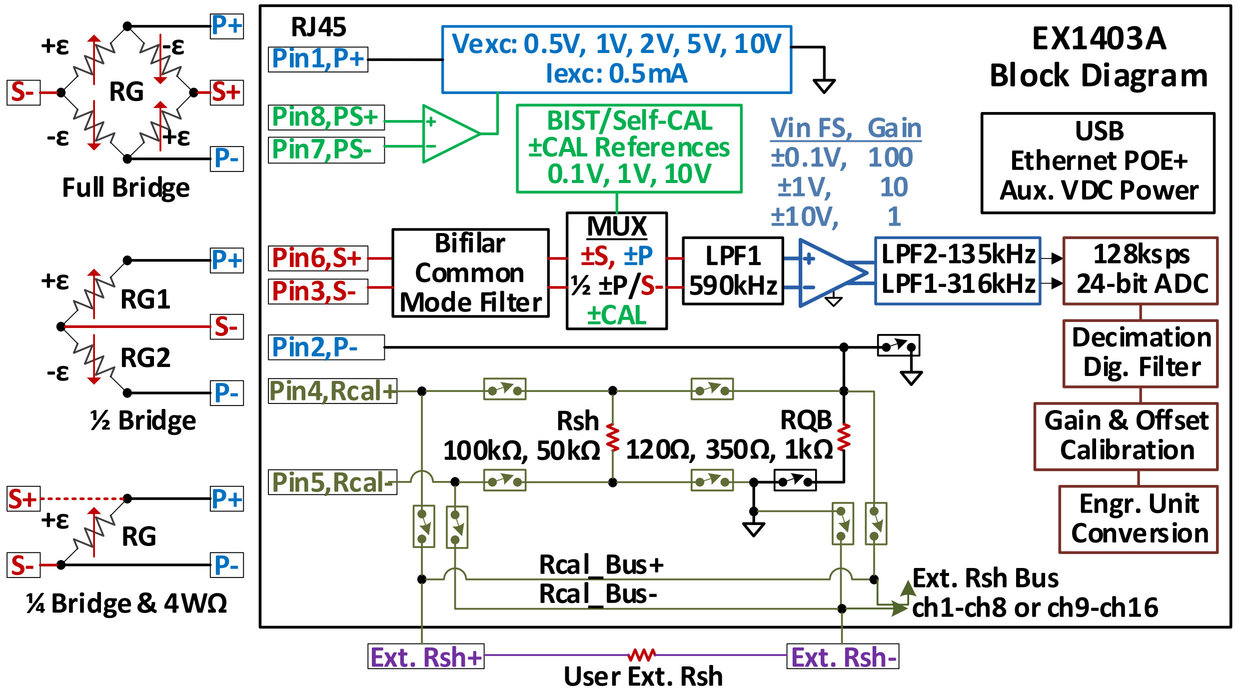


Figure 1-13: Shunt Connection Block Diagram

Each input channel provides individual precision 50kΩ and 100kΩ internal shunt resistors (Rsh) with a temperature stability of 12PPM/°C. The total shunt resistance RSH which includes the ON resistance of the switches are measured with 0.05% accuracy and stored in memory. RSH can be applied to shunt the internal quarter-bridge completion resistor or to shunt remotely any of the arms of the strain gage bridge transducer. All 16 input channels can be shunted simultaneously since there is a shunt resistor per channel.

If an alternate shunt resistor is required, an external resistor may be connected into each of two front panel connectors, one for each group of 8 input channels. The external shunt resistor can be applied to the internal quarter-bridge completion resistor or remotely to the quarter-bridge or one of the active arms of the full-bridge or half-bridge strain gage. The two front panel shunt resistors can be applied simultaneously to only one channel of the corresponding group of 8 channels.

The EX1403A can compute a gain correction factor that compensates for errors due to lead wire, excitation, internal gain errors, and temperature. Shunt calibration is performed by first measuring the voltage imbalance ($V_{unstrained}$) of the bridge when the strain gage is unstrained (0με), and then measuring the strain (ε_{Shunt}) produced when RSH is connected across the internal ¼ bridge completion or remotely across the gage RG through the ±RCAL lines (pins 4 & 5 in RJ-45 input connector).

For highest accuracy, the value of this external shunt resistor should be precisely known. The circuit path resistance up to connection switches is approximately 18Ω±2Ω (Note that the 2Ω uncertainty only represents a 0.004% uncertainty for the 50kΩ shunt and 0.002% for the 100kΩ shunt).This path resistance should be added to the externally connected resistance value, for determining the absolute value of resistance, which would be used in the calculation of theoretical simulated equivalent strain produced by the shunt resistor. The connection resistance is the same for local or remote connection.

The equation below shows the ideal equivalent strain produced by remotely shunting one arm of the strain gage RG (the one connected between P+ & S-) with a shunt resistor RSH. Accuracy of the resistance of the gage RG and the shunt resistor RSH determine the resulting accuracy that can be achieved with shunt calibration.

$$\varepsilon_{IdealShunt} = \frac{\Delta R}{R}\frac{1}{GF} = \left[\frac{1}{GF}\right]\left[\frac{-RG}{RG + RSH}\right]$$

The equation below shows the ideal equivalent strain produced by applying the shunt resistor RSH across the internal quarter bridge completion resistor RQB or the arm connected between P- & S- in a half-bridge or full-bridge transducer. Accuracy of the resistance of the quarter bridge completion RQB and the shunt resistor RSH determine the resulting strain accuracy that can be achieved with shunt calibration.

$$\varepsilon_{IdealShunt} = \frac{\Delta R}{R}\frac{1}{GF} = \left[\frac{1}{GF}\right]\left[\frac{RQB}{RSH}\right]$$

The firmware in the EX1403A can automatically select the appropriate formula to use based on the polarity of the strain produced when applying the shunt resistor RSH.

The resistance values for the internal quarter bridge completion resistors RQB and the shunt resistors RSH are measured with less than 0.05% accuracy and their values are stored in memory for use to calculate the shunt calibration correction factor.

The figure below shows a screenshot of the “Advanced Strain Setup” window of the built-in Soft Front Panel (SFP) that allows the user to measure Vunstrained (zero the bridge) and perform a gain shunt calibration or measure lead wire resistance.

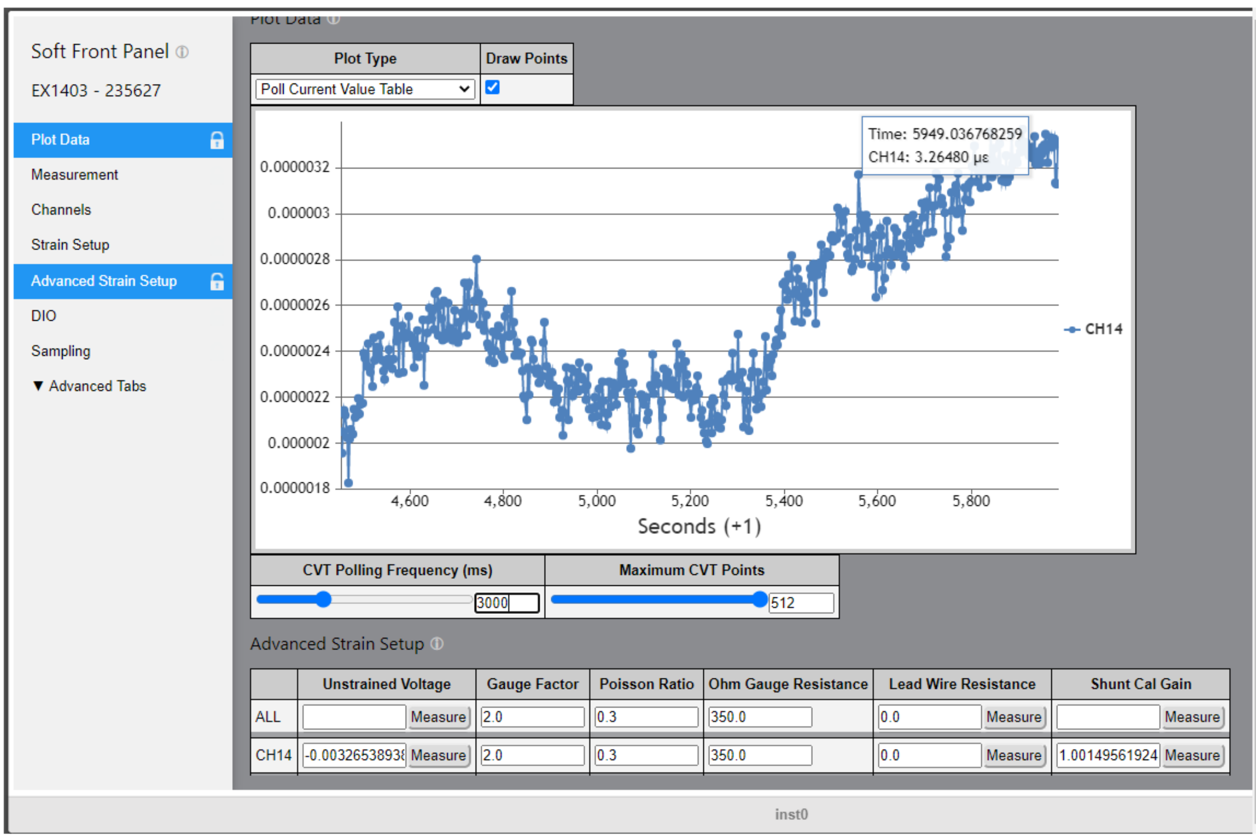


Figure 1-14: Soft Front Panel – Advanced Strain Setup Window

Quarter Bridge Shunt Calibration

The figure below shows the connection for a quarter bridge to the EX1403A. The minimum connection required is P+, P-, and S-. Connecting Rcal+ and Rcal- allows for remote shunt calibration. Connecting S+ allows for the EX1403A to be placed in 4Wire-Ohms mode and measure the gage resistance RG to calculate the ideal equivalent strain ($\varepsilon_{IdealShunt}$) produced by the shunt RSH.

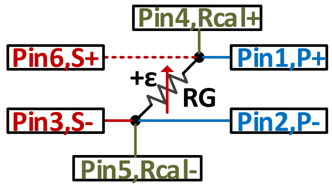


Figure 1-15: Quarter Bridge Connection for Shunt Calibration (S+ connection is optional)

The figure below shows the accuracy obtained after performing a remote shunt calibration using a Vishay 1550A Strain Calibrator in quarter bridge configuration with a 0.035% gain accuracy and an EX1403A that exhibited a ~0.25% gain error. The EX1403A was initially calibrated with the fan turned ON/HIGH with an internal temperature of ~42°C. The fan in the EX1403A was then turned OFF which increased the internal temperature of the unit to ~52°C and introduced the ~0.25% gain error.

EX1403A was set to 10SPS, 5V excitation, Quarter-bridge strain. The EX1403A measured strain with an accuracy of ± [0.03% Rdng + 2με] using either 0.1V or 1V ranges matching the accuracy of the Vishay calibrator. The 2με error is due to offset drift from low frequency noise and temperature variation during the test.

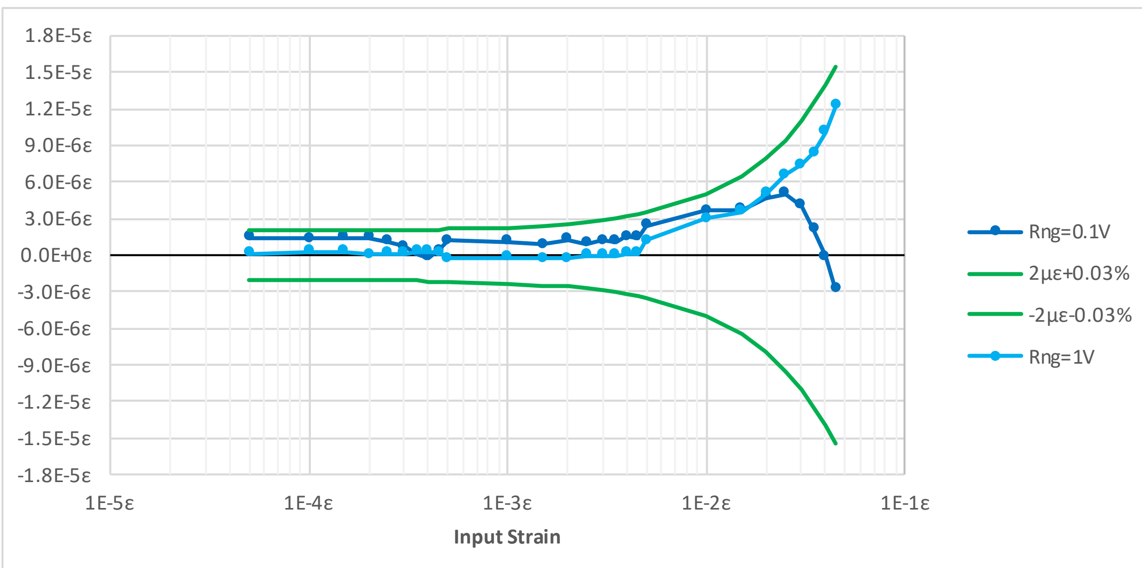


Figure 1-16: QUARTER BRIDGE Strain Error After Remote Shunt Calibration

Shunting the internal bridge completion resistor RQB can also achieve the same accuracy as remotely shunting the gage RG but only if lead wire resistance RL on both the P+ and P- connections are the same. Accuracy of internal shunt calibration is determined by how accurately we know the resistances of RQB & RSH and the RL mismatch [ΔRL = (RL_P+) - (RL_P-)]. The error introduced by the RL mismatch is ΔRL/RG.

Best accuracy is achieved by remotely shunting the gage RG using the ±RCAL lines and accuracy is determined by how accurately we know the resistances of RG & RSH. Remote shunt calibration corrects for errors introduced by lead wire resistance even if there is an RL mismatch, and it also corrects for signal conditioning gain errors introduced by using the unit at a temperature that is different from the temperature at which it was calibrated. Note that even a unit that is out of calibration can be used if remote shunt calibration is performed if RG & RSH are known accurately.

The EX1403A can measure the actual resistance of RG in 4Wire-Ohms (4WΩ) mode. Note that the resistance of RG must include the resistance change caused by the bridge imbalance introduced by the installation. The RG value provided to the EX1403A should be [(1-2*imbalance_in_ε) * RG@0ε] to obtain the best shunt calibration. For example, a 350Ω gage with a +200με imbalance corresponds to a -0.04% resistance change from the gage nominal value, hence the value of RG provided to the EX1403A should be [(1-0.0004) * 350]=349.86Ω. This estimation can be avoided by connecting the S+ line to have the EX1403A measure the resistance of RG after installation.

The procedure to perform a remote shunt calibration is:

1) Set Ex1403A to Strain Quarter Bridge (select appropriate bridge completion) and Range=0.1V
2) Set desired voltage excitation
3) Wait for >30 minutes for gage and bridge completion for thermal stabilization
4) Measure Vunstrained multiple times to verify that it is <10mV and stable
5) Set EX1403A to 4WΩ and measure RG
6) Store measured RG in EX1403A
7) Set EX1403A to Strain Quarter Bridge (select appropriate bridge completion) and Range=0.1V
8) Measure Vunstrained
9) Measure Shunt CAL Gain
10) Start test

Steps 8 & 9 can be executed multiple times without having to repeat the previous steps

HALF BRIDGE SHUNT CALIBRATION

The figure below shows the connection for a half bridge to the EX1403A. The minimum connection required is P+, P-, and S-. Connecting Rcal+ and Rcal- allows for remote shunt calibration. Connecting S+ allows for the EX1403A to be placed in 4Wire-Ohms mode to measure the resistance RG1 or RG2 of the arm being shunted to calculate the ideal equivalent strain ($\varepsilon_{IdealShunt}$) produced by the shunt RSH. Note that RG=RG1+RG2

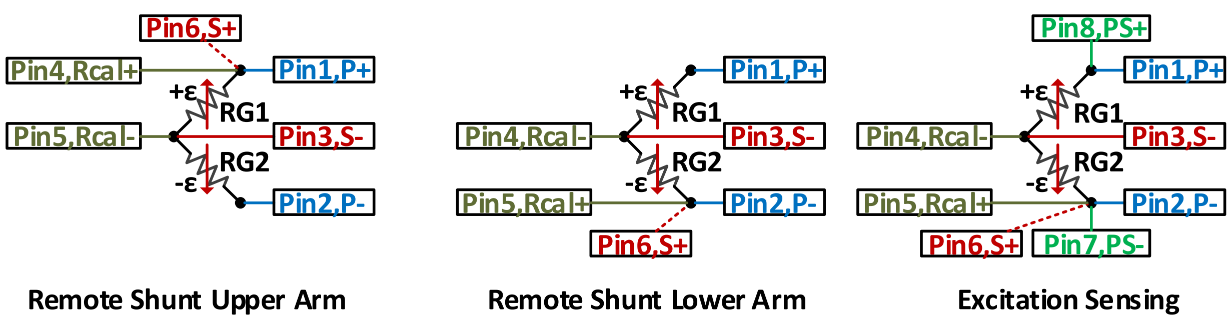


Figure 1-17: Half Bridge Connection for Shunt Calibration (S+ connection is optional)

The figure below shows the accuracy obtained after performing a remote shunt calibration using a Vishay 1550A Strain Calibrator in half bridge configuration with a 0.07% gain accuracy and an EX1403A that exhibited a ~0.25% gain error.

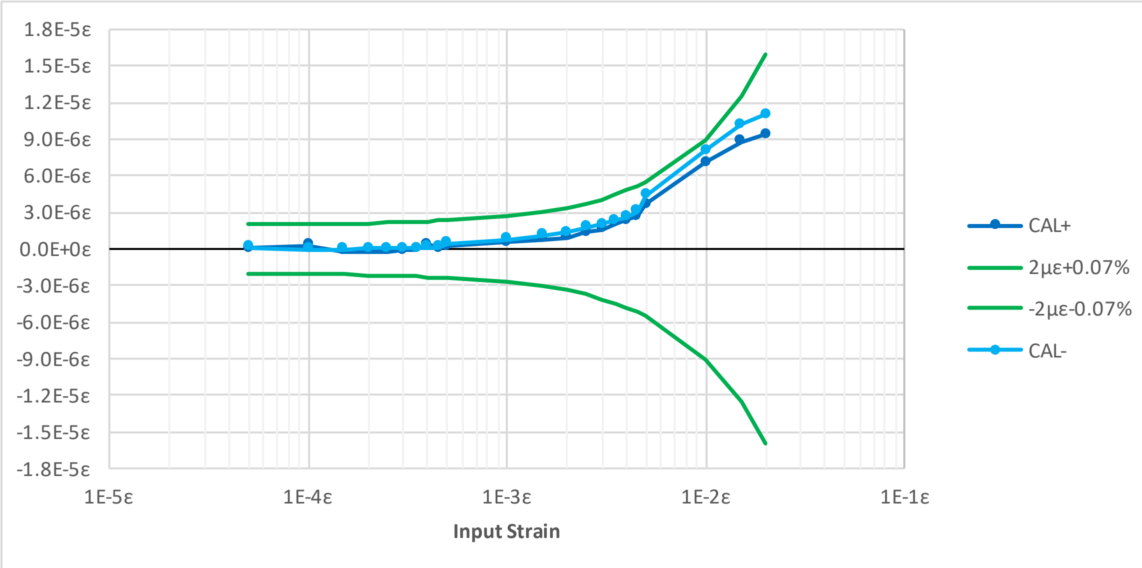


Figure 1-18: HALF BRIDGE Strain Error After Remote Shunt Calibration

EX1403A was set to 10SPS, 5V excitation, half bridge strain. The EX1403A measured strain with an accuracy of ± [0.07% Rdng + 2με] by either shunting the upper arm (CAL+) or lower arm (CAL-) of the Vishay half bridge strain calibrator.

Accuracy of calibration by shunting only 1 arm of the half bridge is determined by how accurately we know the resistances of the gage RG, the shunt RSH and the RL mismatch [ΔRL = (RL_P+) - (RL_P-)]. The error introduced by the RL mismatch is (ΔRL/2)/RG. Lead wire error can be eliminated by connecting the excitation sense lines PS+ and PS-.

FULL BRIDGE SHUNT CALIBRATION

The figure below shows the accuracy obtained after performing a remote shunt calibration using a Vishay 1550A Strain Calibrator in full bridge configuration with a 0.07% gain accuracy and an EX1403A that exhibited a ~0.25% gain error.

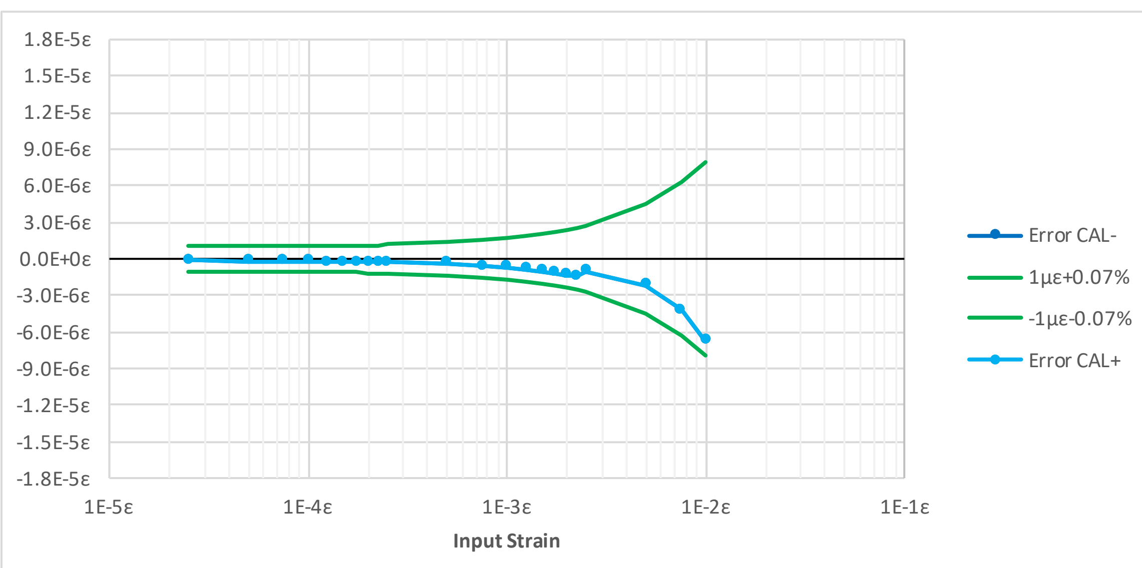


Figure 1-19: FULL BRIDGE Strain Error After Remote Shunt Calibration

EX1403A was set to 10SPS, 5V excitation, half bridge strain. The EX1403A measured strain with an accuracy of ± [0.07% Rdng + 1µε] by shunting any one arm of the Vishay full bridge strain calibrator.

Any of the 4 arms can be shunted if the strain gage produces equal strain in each of the 4 arms.

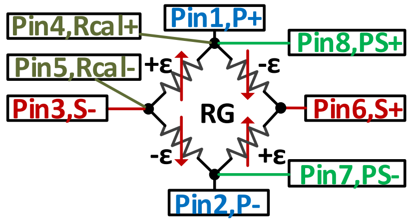


Figure 1-20: Full Bridge Connection for Shunt Calibration

Strain Lead Wire Calibration

Lead-wire resistances in series with the ±P excitation lines attenuate the voltage excitation and desensitize the bridge. Remote excitation sensing lines ±PS can be used to compensate for the voltage loss across lead wire resistances and assure the desired voltage excitation is present across the bridge sensor.

EX1403A can compensate for the desensitization caused by lead wire resistance RL if ±PS lines are not connected by measuring the lead wire resistance RL and computing the correction factor (1+RL/RG). It is usually assumed that RL is the same for both the P+ and P- connections, but the right resistance must be used if they are not the same. EX1403A measures the appropriate resistance depending on the bridge configuration.

Accuracy of the lead wire calibration is determined by how accurately RL is known (RL_error). The accuracy of the correction factor is RL_error/RG. This Lead wire correction factor does not correct for signal conditioning gain errors due to temperature.

Quarter Bridge Lead Wire Calibration

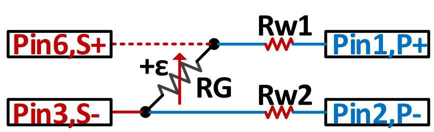


Figure 1-21: Lead Wires for Quarter Bridge Connection

The lead wire resistance RL that should be used for correcting a quarter bridge is the one for the P+ connection: RL = Rw1. Lead wires Rw1 and Rw2 don’t have to be of equal value for the correction factor to make the appropriate adjustment. The correction factor is (1+Rw1/RG).

Half Bridge Lead Wire Calibration

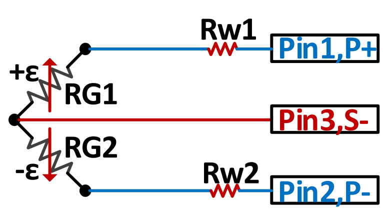


Figure 1-22: Lead Wires for Half Bridge Connection

The lead wire resistance RL that should be used for correcting a half bridge is the average value for the P+ and P- connections: RL = 0.5*(Rw1+Rw2). Lead wires Rw1 and Rw2 don't have to be of equal value for the correction factor to make the appropriate adjustment. RG=RG1+RG2. The correction factor is [1+(Rw1+Rw2)/(RG1+RG2)].

FULL BRIDGE LEAD WIRE CALIBRATION

The lead wire resistance RL that should be used in the formula for full bridge is the total RL for the P+ and P- connections.

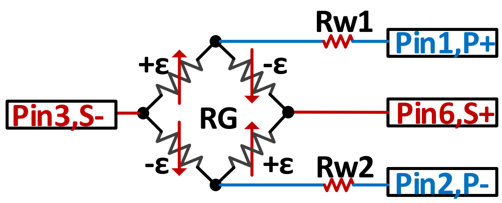


Figure 1-23: Lead Wires for Full Bridge Connection

The lead wire resistance RL that should be used for correcting a full bridge is the sum of the P+ and P- connections: RL = (Rw1+Rw2). Lead wires Rw1 and Rw2 don't have to of equal value for the correction factor to make the appropriate adjustment. The correction factor is [1+(Rw1+Rw2)/RG].

SECTION 2

PREPARATION FOR USE

UNPACKING EX1403A

When the EX1403A is unpacked from its shipping carton, the contents should include the following items:

- EX1403A Strain/Bridge Digitizer(70-0655-100R)
- EX1403A Quick Start Guide
- EX14XX AC/DC Power Supply 60W (56-0739-000R)
- Ground cable (53-0070-072R)

All components should be immediately inspected for damage upon receipt of the unit.

EX1403A User Manual, EX1403A Product Drivers are available at https://www.powerandtest.com/ate-data-acq/platforms/lxi/ex1400-family/EX1403A/. For EXLab Software please visit www.powerandtest.com. IVI shared components are required to be installed for the device identification purpose. The LXI discovery utility (http://lxistandard.org/Resources/LXIDiscoveryTool.aspx) is helpful to discover the EX1403A and other LXI devices connected in the network.

INSTALLATION LOCATION

The EX1403A is designed to be largely insensitive to external electrical, magnetic, and thermal disturbances. However, as with all precision instrumentation, certain precautions, if taken into consideration, can help achieve maximum performance.

11) The unit, particularly its front panel, should be located away from sources of high or low temperatures. When used in a rack-mount application with other heat-generating instruments, the EX1403A should be located away from the other instruments as possible, 1U minimum. Multiple EX1403A units, however, can be stacked directly on top of one another without any performance degradation.
12) The front panel of the EX1403A should not be exposed to strong air currents. Typical problematic sources include building ventilation and instrument or cabinet fans.
13) The unit should be located away from sources of high magnetic fields such as motors, generators, and power transformers.
14) The fan air outlet at the rear side of EX1403A should not be blocked.

LOCATION OF CONNECTORS

Given below are the locations of various buttons, indicators and connectors on EX1403A.

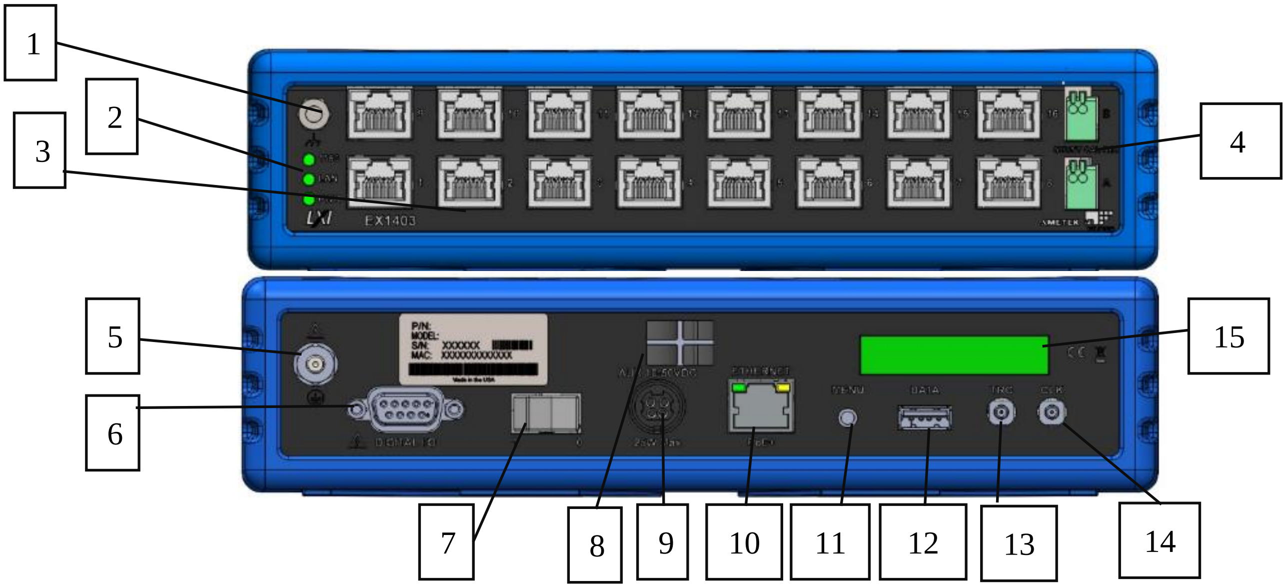


Figure 2-1: Rack Shelf Installation Diagram

1. Earth point socket (1/4"-32 THREAD, THRU-HOLE)
2. LXI System status indicators
3. Analog Input Connector (RJ45)
4. External Shunt Connectors
5. Chassis Earth point stud, Safety ground (M3 X 16mm, 4.5mm HEX)
6. Digital IO port (Standard D-Sub 9 pin Female/Socket)
7. Power Switch
8. Cooling fan exhaust
9. Auxiliary power connector
10. Ethernet/LAN Port (PoE+ enabled)
11. Menu Button
12. USB 2.0 host port (Type A Female) for external data logging disk drive
13. Trigger Connector (Standard SMB Male)
14. External Clock Connector (Standard SMB Male)
15. Display
   15)

INSTALLATION OPTIONS

The EX1403A can be optionally rack mounted, using the rack mount kit accessory (P/N: 70-0626-900). This must be installed prior to installation into the rack. This option is not included with the EX1403A and must be ordered separately, if needed.

Rack-shelf Installation Option of EX1403A

The shelf/tray installation option includes all the parts necessary to mount the EX1403A to the front of a standard test rack.

Required Tools

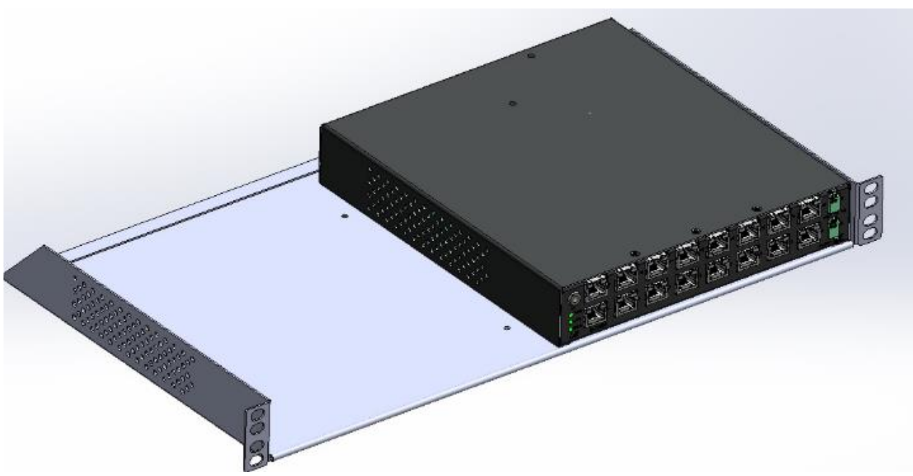
#2 Phillips screwdriver

Parts List

Item#	Qty	Description	VTI P/N
1	1	EX14XX-RK001, Rack Mount Kit	70-0626-900R
2	4	Screw, 4-40 x 3/16", Flat 82° Undercut Phillips, Black Oxide	

Assembly Procedure

1) Place the chassis on a protected work surface with its input connectors facing front.



2) Using a #2 Phillips screwdriver, install the rack shelf/tray on the bottom of the EX1403A using four (4) 4-40 x 3/16", Flat 82° Undercut Phillips, Black Oxide screws, as shown in below diagram.

Figure 2-2: Rack Shelf Installation Diagram

Tabletop Installation Option

The tabletop installation option can be used when the EX1403A will not be installed in a rack, but will be employed as a bench top or desktop instrument.

Required Tools

#2 Phillips screwdriver

Parts List

Item#	Qty	Description	VTI P/N
1	4	Screw, M3 X 5mm SOCKT HD, HEX, SS	37-1801-005R
2	2	Bezel, Cap, EX1403A Chassis	

Assembly Procedure

1) Place the chassis on a protected work surface, upside down, with its input connectors facing front.
2) Using Figure 2-3, locate the installation locations (on the bottom of the chassis) for each rubber cap bezel.
3) Using the #2 Phillips screwdriver, install the four rubber feet using four (4) M3 X 5mm SOCKT HD, HEX, SS screws to secure the bottom.

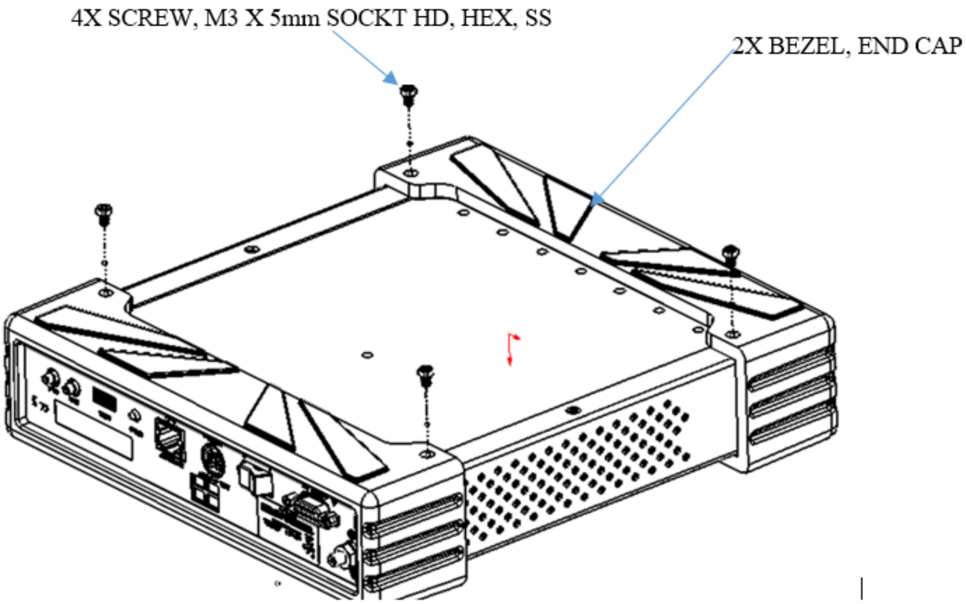


Figure 2-3: TABLETOP Feet Installation Diagram

Figure 2-4: EX1403A Sample Rack MOUNT KIT Installation

WARM-UP TIME

The specified warm-up time of the EX1403A is 45 minutes. If, however, the unit is being subjected to an ambient temperature change greater than 5 ºC, extra stabilization time is recommended to achieve maximum performance.

POWERING UP AND GROUNDING

The EX1403A is designed to be powered by a DC power source. It can be provided by either using a PoE+ enabled Ethernet port (which injects DC power into the network lines, such that there is no need of additional wiring), or through an external DC power adaptor. Many PoE+ enabled switches are compatible with EX1403A. Some of the PoE+ switches that have been tested for compatibility are listed below.

- Cisco SF302-08PP (8-port PoE+ managed switch)
- Intellinet Model 560856 (8-port PoE+ switch)
- Trendnet TPE-115I/A (Power Injector)

The maximum power consumption of the unit is 25W. The unit accepts and performs within the specifications when the Auxiliary Supply voltage is between $+10V_{DC}$ to $+50V_{DC}$. The power inputs are protected for reverse polarity by up to 50V in reverse direction. If the AUX input connector is used to supply power to the unit, then the power supplied must be isolated from earth ground by 1500Vrms to maintain isolated Ethernet. (The AUX negative terminal is connected to one side of the Ethernet's twisted pair common mode.)

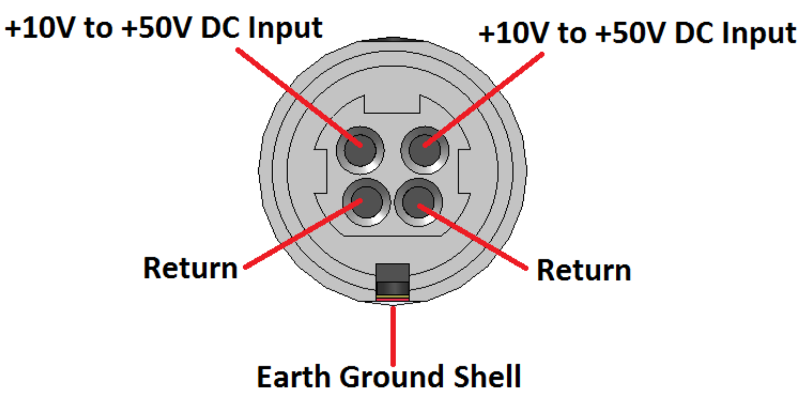
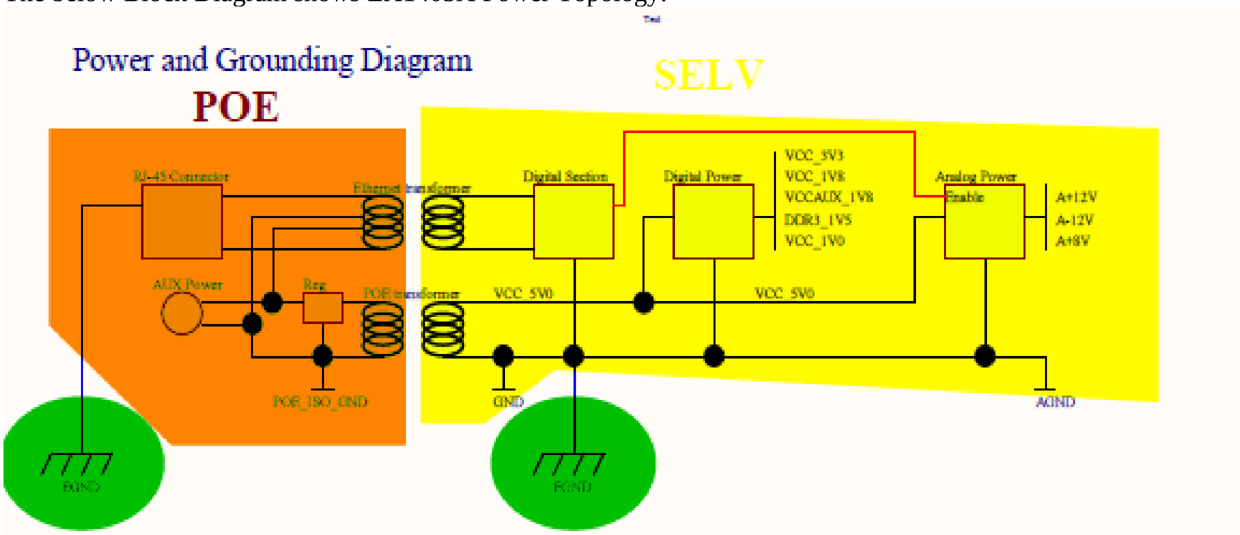


Figure 2-5: Aux DC In connector Pinout

The power inputs (both POE+ and AUX DC IN) are isolated from chassis, as are the analog inputs and digital IO. Hence users are required to earth ground the EX1403A chassis for safe operation. The safety ground connection is on the rear panel and is required to be connected to the local earth ground using the provided cable (VTI# 53-0070-072R). Do not use the banana jack on the front panel for earth grounding the EX1403A. This connector is for reference only and is not meant to be a safety ground connection. The front side connector is a standard Banana socket (ITT Pomona 3267), while the rear side connector is 10-32 size stud.

EX1403A Safety Precautions

The EX1403A is designed to be powered by an isolated DC power source complying with the requirements for reinforced insulation. It can be provided by either using a PoE+ enabled Ethernet port (which injects DC power into the network lines, such that there is no need of additional wiring), or through an external isolated DC power adaptor. The below Block Diagram shows EX1403A Power Topology.



SELV

Figure 2-6: EX1403A Power and Grounding

Many PoE+ enabled switches are compatible with EX1403A. Please refer POWERING UP AND GROUNDING for Some of the PoE+ switches that have been tested for compatibility and qualified for safety.
The POE and Aux power input's must be from an isolated source of supply complying with SELV and reinforced insulation requirements

The unit accepts and performs within the specifications, when the Auxiliary Supply voltage is from an isolated source complying with the requirements for reinforced insulation, between +10VDC to +50VDC. The power inputs are protected for reverse polarity by up to 50V in reverse direction. If the AUX input connector is used to supply power to the unit, then the power supplied must be isolated from earth ground by 1500Vrms to maintain isolation. The AUX supply must be SELV and isolated from the primary by reinforced insulation.
(The AUX negative terminal is connected to one side of the Ethernet's twisted pair common mode.)
When using the AUX DC Input to power your unit, VTI recommends using external supply (VTI# 56-0739-000R, this power adapter is shipped by default with EX1403A) or (VTI# 56-0739-120R, this power adapter is an optional PSE certified power adapter to be purchased separately). It meets ITE Safety standards viz. IEC60950-1 (Ed.2,2005)

Note-1: If desired, a different DC supply can be used if it meets the voltage, power, connector, and safety requirements. Use a power source that meets the same safety and CE requirements listed on the declaration of conformity for this product.

The power inputs (both POE+ and AUX DC IN) are isolated from chassis and digital IO. Hence users are required to earth ground the EX1403A chassis for safe operation. The safety ground connection is on the rear panel and is required to be connected to the main protective earth ground using the provided cable (VTI# 53-0070-072R). Do not use the banana jack on the front panel for earth grounding the EX1403A. This connector is for reference only and is not meant to be a safety ground connection. The front side connector is a standard Banana socket (ITT Pomona 3267), while the rear side connector is 10-32 size.

Note-2: This product shall not be connected to public telecom network
Note-3: Please note that all the channel inputs are SELV only. The maximum analog input voltage is limited to +/-10V for all conditions.

ıcated on the back the unit.

Tool utility (a free tool available from LXI
[rg/Resources/LXIDiscoveryTool.aspx]

AN Subnet. It uses mDNS and VXI-11 protocols to
pple Bonjour Print Services"in order to use mDNS
ry to install this service, since the EX1403A can

ows, there is an IVI driver based on the industry standard IVI driver architecture specifications. The IVI driver exposes both IVI-COM and IVI-C interface APIs. The IVI-COM interface can be used from any programming language that supports Microsoft COM (Component Object Model). For Linux, there is a driver that provides a C++ API. Both Windows and Linux drivers have a consistent API design so that the application software developed for one can be easily migrated to the other. The drivers are compatible with both 32-bit and 64-bit operating systems. In general, the API descriptions in this document apply to both the Windows and Linux drivers unless otherwise specified.

To control the EX1403A series instruments programmatically (via a user generated program or through tools such as Keysight VEE®, NI LabVIEW®, MathWorks MATLAB®, etc.), two additional components must be installed: the IVI Shared Components library (for Windows OS only) or the VTI Common Library (for Linux OS only) and the provided VTI Instruments driver. For 32-bit Windows OS, install the 32-bit driver. For Windows 7 (64-bit), Windows 8 (64-bit), and Windows 10 (64-bit), the 64-bit driver installer includes both 64-bit and 32-bit compatible drivers. These drivers are available for free download on the Ametek Instruments web portal (www.powerandtest.com), in the respective product page, under download tab. The following sections describe installing the required software.

IVI Shared Components Installation (Windows Only)

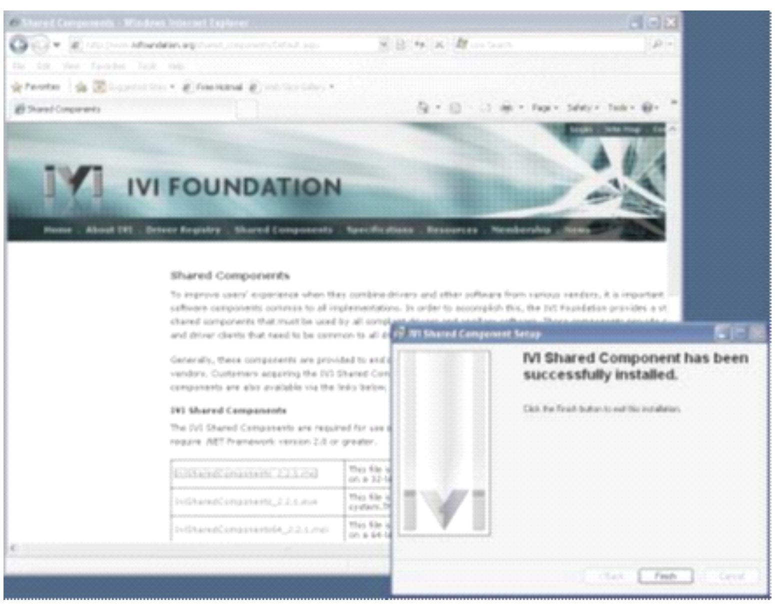


Figure 2-7: IVI Shared Component Installation

If this component was installed during a previous LXI instrument installation, please proceed to Instrument Driver Installation. First, close all other open programs, leaving only Windows Explorer open. Navigate to the `<CD-ROM Drive>:\EX Platform Requisites` directory on the CD and run the `IVISharedComponentsX.X.X.exe` program. Next, follow the on-screen instructions. Do not proceed to the next step until this installation completes successfully. If instructed to reboot the PC, it will be necessary to do so at that time. Alternatively, the latest IVI shared components can be downloaded and installed from IVI Foundation Web page, www.ivifoundation.org.

Instrument Driver Installation

If the VTEXDigitizer instrument driver was installed previously on the host PC, you may skip this step of the installation process, and proceed to Platform/LXISync Instrument Driver Installation. The previously installed driver may need to be updated to the most recently released version to support the EX1403A. To install the VTEXDigitizer instrument driver, navigate *to* `<CD-ROM Drive>:\Drivers\LXI Drivers\EX Series`, on the CD, open the appropriate zip file in this directory, and then run the `.msi` installer. Alternately the drivers are available for free download from VTI Instruments online portal (www.powerandtest.com) under the specific product's download page.

Figure 2-8: Instrument Driver Installation

The Linux driver (32-bit and 64-bit) is located under `<CD-ROM Drive>:\Drivers\Linux Drivers\Linux EX Series`. Open the appropriate zip file in this directory and then run the RPM Installer. Alternately the instrument drivers for Linux OS are also available for free download from VTI Instrument website, (www.powerandtest.com),

Platform/LXISync Instrument Driver Installation

NOTE	Complete this step only if the LXISync capabilities of the EX platform are required. If this driver was installed previously on the host PC, software installation is now complete.

To install the Platform/LXISync Instrument driver, navigate to *<CD-ROM Drive>:\LXI Drivers\EMX Platform Driver*, *IVI* on the CD and run the .msi installer located in this directory. Please refer to the VTEX Digitizer Driver's online help file for programming guidelines. Additional information about IVI drivers can be found on the web at http://ivifoundation.org. Information about the LXI standard and LXI technology can be found at http://www.lxistandard.org.

NETWORK CONFIGURATION

By default, the EX1403A will attempt to locate a DHCP server. If one is found, the IP address assigned by the DHCP server will be assumed. Otherwise, after a timeout of 20 seconds, the unit will attempt to obtain an IP address by using Auto IP.

Auto IP is a mechanism for finding an unused IP address in the range 169.254.X.Y where X is in the range 1 - 254 and Y is in the range 0 - 255. The device will first attempt to obtain the specific address 169.254.X.Y, where X and Y are the second-to-last and last octets of the device's MAC address. However, X will be set to 1 if it is 0 in the MAC address, and to 254 if it is 255 in the MAC address. If this address is already in use, the unit will attempt to obtain other IP addresses in a pseudorandom fashion until it finds one that is available.

To illustrate the Auto IP mechanism, Table 2-1 lists the Auto IP default address for some example MAC addresses.

MAC Address	Auto IP Default Address
00:0D:3F:01:00:01	169.254.1.1
00:0D:3F:01:01:01	169.254.1.1
00:0D:3F:01:A3:28	169.254.163.40
00:0D:3F:01:FE:FE	169.254.254.254
00:0D:3F:01:FF:FE	169.254.254.254

Table 2-1: Auto IP Default Address Assignment

If a static IP address assignment is preferred, one can be optionally assigned via the embedded web page interface. This is done by clicking the **Network Configuration** link, disabling DHCP, and then assigning a static IP address.

However, a much more convenient and recommended way to obtain the benefits of a static IP address is to employ DHCP but assign the instrument a reserved IP address in your company's DHCP server configuration. This reserved address, linked to the EX1403A's MAC address on the DHCP server, would be assigned to the EX1403A at power up initialization without having to manually set it on the EX1403A. The DHCP server configuration provides a centralized, controlled database of assigned IP addresses, preventing accidental assignment of the same IP address to multiple instruments. Consult your company's Information Technology department for assistance.

VXI-11, and mDNS Device discovery methods are supported by the EX1403A. This allows all EX1403As on a local network to be found without knowledge of their MAC address or IP address with the use of a broadcast message. Also, the LCD display on the EX1403A provides the current IP Address configuration of the instrument, at any given instant. Refer to IPv4 Address in Section 3 for more details on LCD menu operation.

Network Configuration Reset for EX1403A

There is no dedicated network reset button on the EX1403A. The "menu" button cycles through different screens on the LCD display. On the LAN Reset page, holding the menu in for more than 4 seconds will initiate a LAN Reset. The screen counts down as you hold in the button and releasing the button during this stage will abort the reset operation.

The LAN Reset is useful for recovery from an incorrect or unknown network configuration. Note that the LXI reset function is not a processor reset or reboot. Initiating a LAN Reset will:

1) Enable DHCP and AutoIP
2) Disable Static IP
3) Set the mDNS hostname and service name to the last user-configured values, or the factory default values if the user has not changed those values
4) Enable IPv6. Remove the password (if any)
5) Set the time source to PTPv2 (if it was set to Manual or NTP)
6) Set the LXI event domain to 0

NETWORK TROUBLESHOOTING

If an error occurs, when trying to discover the EX1403A you may refer to *Common Issues* in Section 4 If none of these resolutions help resolve the network connectivity issue, it may be necessary to change the network settings for the EX1403A and the host PC. By using the following methodology, most network-related issues can be resolved:

1. Navigate to the IPv4 address status page on the LCD screen using the menu button
2. Note the current IP address and subnet details which are currently assigned to the instrument
3. Note the current network configuration of the PC, and get ready to change the IP address
4. Change the IP address of the PC, such that it will be compatible with EX1403A network
5. Disable all network interfaces (including WiFi) except that wired network, which is connected to the EX1403A mainframe
6. Connect the EX1403A to PC directly through Ethernet cable. Since EX1403A supports auto MDI-X feature, either Direct cable or Cross cable can be used to connect to the PC.
7. Open the embedded SFP webpage, of EX1403A and navigate to Network Configuration page
8. Make changes to the network as you need, and remember to “submit” the changes
9. Power cycle the EX1403A instrument
10. You can now disconnect the EX1403A instrument from PC, and change the PC Network configurations again, as needed.

Using Multiple Network Cards

When multiple network cards exist in a single PC, it may be necessary to define a static IP address to both the host PC NIC card that will interface with the EX1403A instrument as well as the EX1403A instrument itself. This process is only necessary if a DCHP server is not connected to the network to which the device is connected and typically occurs when the NIC is connected directly to the instrument.

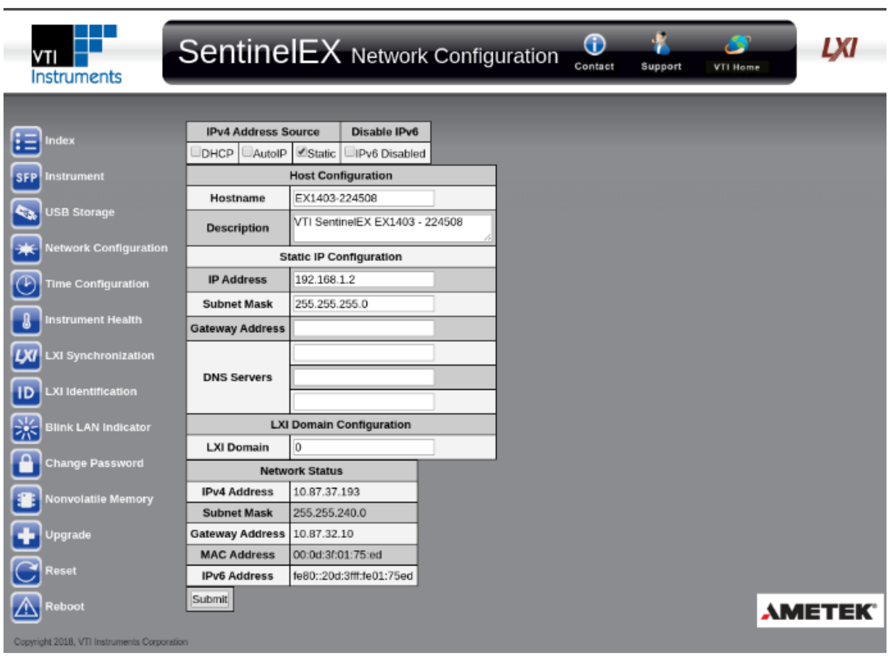


Figure 2-9: Completed EX1403A Mainframe Static IP Configuration

The following process can be used to ensure proper functionality:

1) Navigate to Start → Settings → Network Connections.
2) Disable all network interfaces except the one that is connected to the EX1403A mainframe. This is done by right clicking on the interface, then selecting **Disable**.
3) Open the web page of the EX1403A mainframe.
4) Click the **IP Configuration** link. A prompt may appear to log into the EX1403A mainframe.

5) Unselect **DHCP** and **AutoIP** and ensure that **Static** is selected.
6) Enter an IP address into the **IP Address** field. For more information on valid IP addresses, please consult with an IT administrator.
7) Set the Subnet Mask.
8) Click the **Submit** button. Once this is done, it is no longer possible to communication with the EX1403A mainframe. This is normal and is addressed in the following steps.
9) Set a static IP address for the NIC card by doing the following:

   a) Navigate to Start → Settings → Network Connections.
   b) Right click on the NIC card that the EX1403A mainframe is connected to and select Properties.
   c) Select Internet Protocol (TCP/IP) and click Properties.

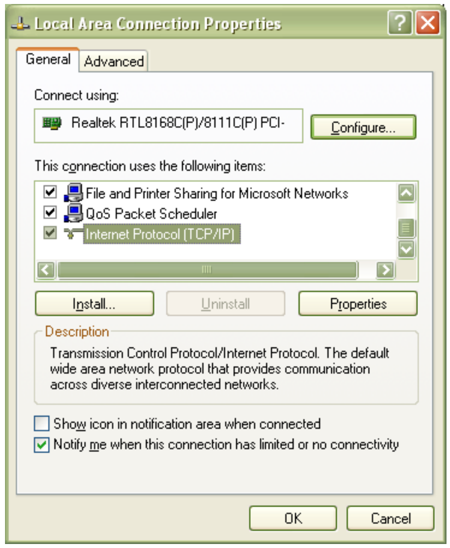


Figure 2-10: TCI/IP Selection

   d) Click the Use the following IP address radio button.
   e) Enter the desired IP address.
   f) If not automatically completed after the IP address is entered, set the **Subnet mask** field to suitable address range.
   g) Click OK to exit the network configuration properties

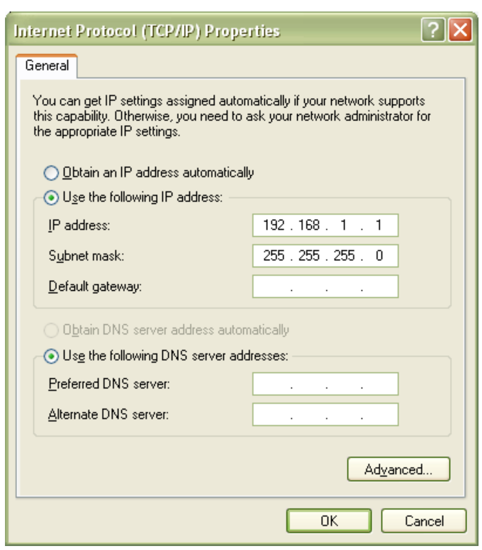


Figure 2-11: Completed NIC Static IP Configuration

TIME CONFIGURATION

By default, the EX1403A will be configured to receive its time through PTPv2 (Precision Time Protocol). The user can also set time using SNTP (Simple Network Time Protocol) or the time can be set manually. The manual setting is necessary if the network environment is such that the unit cannot reach the Internet/Intranet time server. For more information, see Time Configuration in Section 4.

SECTION 3

BASIC OPERATION

INTRODUCTION

This section expands on the description of the EX1403A's features and explains how to best use them.

ENGINEERING UNIT (EU) CONVERSION

Each EX1403A input channel can be individually configured for bridge/strain and voltage measurements. The EX1403A provides ±0.01 V, ±1.0 V, and ±10.0 V voltage measurement ranges on all input channels. Voltage measurement range is programmable on a per-channel basis. The default selection for voltage channels is the ±10 V range.

HARDWARE/ANALOG ANTI-ALIAS FILTER

Each EX1403A input channel has a fixed, 2-pole, 65kHz RC low pass filter for anti-alias filtering.

DIGITAL FILTER

The EX1403A allows the user to configure different types of digital filters per channel. These digital filters are implemented inside the FPGA of the device, such that they perform consistently and without loading the host computer resources. Users can optimize the filter settings for aggressive filter performance or lower data latency time. In addition, users can customize the FIR filter performance by editing the coefficients of the filter. This provides ultimate flexibility in designing a filter to suit the application needs. The digital filter parameters for each channel can be defined independently. Final data throughput is a complex parameter and depends on the basic sampling rate and digital filter selection. Choosing the correct sampling rate and digital filter parameters is critical for achieving optimum performance levels of common model signal rejection, roll-off rate, and data latency.

LED INDICATIONS

As an LXI standard compliant instrument, the EX1403A instrument provides multiple LED indicators on the front and rear of the instrument to indicate the power, network connectivity and synchronization status.

Power LED (PWR)

This is a single colored LED. If the LED is glowing Solid Green, it indicates that power is applied to instrument, and is in active states.

LAN LED

This is a Bi-color LED (Red/Green), used for indicating the basic network connectivity status. The LED glows in solid green color, when the device is successfully connected to a network, without any conflict/error. If there is a problem with the LAN connectivity, this indicator turns to solid red color. If the LED is blinking/flashing green, it indicates that the Device Identification command was received over the LAN. The status indicator shall continue to flash green until commanded to do otherwise. Refer Blink LAN Indicator section under web page operation section for more details.

IEEE 1588 LED

The IEEE 1588 Clock Status Indicator is designed to show both the status and the type of clock in the EX1403A device. This indicator is a bi-color LED (Red/Green) whose states are identified as follows:

State of LED	PTP Clock/Sync State
Off	Not Slave, Not Master, and Not Faulty
On – Solid Green	Slave
On – Blinking Green once every second	Master but not Grandmaster
On – Blinking Green once every two seconds	Master and also Grandmaster
On – Solid Red	Faulty

Table 3-1: IEEE 1588 LED States

LEDs on Network Port

There are two LEDs present on the RJ45 Ethernet connector, placed on the rear side of EX1403A. The right-yellow LED indicates network activity. The blink rate is roughly proportional to amount of network traffic. The left-bicolor(green/amber) LED indicates connectivity and rate. Green indicates connected at 100Mbps and amber indicates connected at 10Mbps. If both LEDs are off, it indicates that network is not connected. Network connectivity does not mean the device has obtained an IP address or has access to the connected network. The LAN indicator on the front provides that function.

Channel LED Indicators

In addition to the system status indicators, the EX1403A also features LEDs for each channel on its front panel, embedded to RJ45 connectors. The behavior of this LED can be controlled by setting the *Channel.Overload.Indicator* property. This is a mask with the same bit values as the Overload Status described above. Whenever *Channel.Overload.Status & Channel.Overload.Indicator != 0*, the LED will be lit yellow. Otherwise, the LED will be green.

DIGITAL I/O

The EX1403A features an 8-channel digital I/O port on the rear panel of the instrument. This port can be used for various functions, such as arm/trigger source, for presentation of limit evaluation information, and as a general-purpose input/output device. The digital I/O connector is a standard DB-9 with the following pin assignment:

Pin	Function
1	DIO Channel 0
2	DIO Channel 1
3	DIO Channel 2
4	DIO Channel 3
5	DIO Channel 4
6	DIO Channel 5
7	DIO Channel 6
8	DIO Channel 7
9	GND

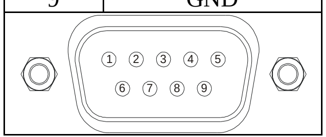


Table 3-2: Digital I/O Connector & Pin Assignment

As a general-purpose output device, each DIO channel can be independently programmed with regards to its output functionality and its logic state, when enabled as an output. When not enabled as an output, a channel becomes tri-stated, preventing conflict with other potential voltage drivers. Refer the port's electrical specifications for voltage tolerance limits and output drive capabilities. Regardless of output functionality, each channel provides constant input functionality. That is, the input level on each channel can be accessed without a specific enable function call. It is also possible for the DIO data to be acquired and reported along with the analog channel data. Unless linked to a limit condition, as discussed below, the DIO port's operation is completely autonomous.

The default selections for each DIO channel are:

- output enable is off
- output level is 0

The electrical specifications for the digital I/O port are provided in EX1403A Specifications.

The Digital IO port is bank isolated from chassis ground/earth potential for up to ±250VPEAK. However, there is no inter-channel isolation between digital channels. The Digital I/O port is ESD protected on all IO pins. Use a shielded cable when connecting to the Digital IO port for COMMON EARTH.

NOTE	Each Input channel of the Digital IO port is pulled down through 10K Ohm resistor to its ground

TRIGGERING

The EX1403A supports a full function trigger model with a separate arm source and trigger source event structure. For a complete explanation of the trigger model, see Start, Arm, Trigger, and Alarm in Section 5. In summary, an acquisition sequence is enabled with a trigger initialize command. Scanning is then initiated upon the receipt of the programmed arm source event followed by the receipt of the programmed trigger source event. Trigger and arm source events can be independently programmed from a variety of sources including Immediate, Software, External trigger, Digital I/O, and LXI alarms. Channel data levels can also be used as Trigger sources. Analog triggers (channel inputs) are also supported

DATA FORMAT

By default, the data returned during data retrieval is limited to the channel readings and the absolute time of measurement initiation.

ACQUIRING DATA

In general, the acquisition and retrieval of data on the EX1403A are conducted with discrete commands that are often separated in time to a large degree. The EX1403A utilizes a 256 MB FIFO memory storage to buffer acquisition data prior to retrieval. This reading buffer is cleared upon receipt of the trigger initialize command in preparation for reading storage and begins storing new data in a circular buffer immediately. Then, upon fulfillment of the programmed trigger model conditions, the EX1403A marks one or more records in the circular buffer for user retrieval. It continues scanning and storing the acquisition data until the trigger and arm count quantities are reached or the acquisition is aborted. At that point, data acquisition ceases and the trigger model is returned to the Idle state.

The amount of records that can be buffered within the memory is dependent on the number of channels enabled and the requested record size. Specifically, the number of records that can be buffered (Record_Count) is determined by the following formula:

Sample_Size = 4
Record_Bytes = Record_Size * Sample_Size * (Channel_Count + DIO_Reporting)
Record_Count = 268435456 / Record_Bytes

where:	Channel_Count	0-16 (number of channels enabled)
	Record_Size	1-65527 (number of samples per record)
	DIO_Reporting	0 or 1 (1 – YES, 0 – NO)

Regardless of the RecordSize, each channel's circular buffer is then truncated to make its total size evenly divisible by 4096.

Record Count sizes for some typical configurations are the following:

Channel_Count	DIO_Reporting	Record Size	Record Count
1	0	1024	65536
0	1	1024	65536
8	0	1024	8192
16	0	1024	4096
16	0	4096	1024
16	0	1	4194304
16	1	1024	3852
16	1	4096	963

Table 3-3: Example Record Count Sizes

If the circular buffer fills to the point that it would overwrite a record marked for retrieval by a trigger before it has been read out, the instrument will abort the acquisition and return to the Idle state.

NOTE	The reading buffer memory is volatile and is cleared upon an instrument reset or power cycle.

RETRIEVING DATA

Acquisition data can be retrieved from the EX1403A with any of three methods. First, it can be manually read out of the instrument's FIFO sometime after it is measured. This method is the simplest but runs the risk of aborting the measurement early if the data is not retrieved before the 256MB circular buffer is filled. The data can also be streamed to one or more endpoints. Streaming endpoints can include one instrument driver session and any number of attached USB storage devices. When streaming to the instrument driver is enabled, the instrument will send binary encoded data directly to the driver as soon as it becomes available. The instrument driver can then either buffer the data in PC memory for retrieval at the user's convenience, save the data directly to hard disk, or call a user callback with the new data. When a USB storage device is enabled for streaming data, the data will be written directly to the device as soon as it becomes available in the selected file format (HDF5 or CSV).

In either case, retrieved data is fully calibrated and compensated by the EX1403A and output directly in the requested units. No post-acquisition user manipulations are required. In order to provide the maximum reading buffer capacity for future acquisitions, data is deleted from the FIFO memory upon retrieval.

Applications may retrieve data from this FIFO using either the Read FIFO or Streaming Data interfaces. Please refer to Data Acquisition in Section 5 for further details. Once data is retrieved from the FIFO, via any method, it is no longer kept within the FIFO.

USER-DEFINED CONVERSIONS

The EX1403A provides the capability to apply a user gain and offset after the standard EU conversion for the selected Function. These values are exposed via the Channel.Transducer.Conversion property as an array consisting of first the offset, then the gain. The value of data returned will be:

(UserGain * EUValue) + UserOffset

LCD DISPLAY

The display on the rear side of EX1403A is a 20 x 2 backlit LCD. It can display several screens that can be cycled through using the Menu button. Some screens allow you to initiate an action. This is done by holding the menu button in for several seconds. A countdown of remaining seconds is shown while the button is pressed. The action is activated on release of the menu button; releasing before the countdown completes will cancel the action. Screens with actions are LAN Reset, Self-Test, USB Eject, USB Data Logging, and Fan.

Hostname

```
Hostname
EX1403A-681514
```

IPv4 Address

```
IPv4 Address
10.87.37.24
```

If the device does not have an IPv4 address, the display will show "Network unavailable" instead of the IPv4 address.

```
IPv4 Address
Network unavailable
```

IPv6 Addresses

The IPv6 address screens show one or two addresses on two or three screens. Because an IPv6 address is too large to fit on a screen the addresses are split between the HostID, which is the lower 64-bits, and the Subnet, which is the upper-64 bits. If the device does not have a global IPv6 address, it will show as "Network unavailable". If IPv6 is disabled, then all IPV6 screens will show "Network unavailable". Note that the HostID portion is common to both the Local and Global addresses and so is only displayed once.

```
IPv6 Local Subnet
fe80:0000:0000:0000
```

```
IPv6 HostID
020d:3fff:fe01:1f9c
```

```
IPv6 Global Subnet
Network unavailable
```

MAC Address

```
MAC Address
00:0d:3f:01:1f:9c
```

LAN Reset

```
LAN Config Reset
Hold MENU to reset
```

Fan

```
Fan High   2272 RPM
Hold MENU to change
```

Holding MENU will cycle between the three available fan modes: High, Off, and Auto. If the fan is configured for Auto, but internal temperature sensors are below target temperature, the status will be displayed as “Auto (Off)”. If the fan is set to High (or Auto and cooling is required), its current detected RPM will be displayed.

```
Fan Auto (Off)
Hold MENU to change
```

Self-Test

```
Self Test
Hold MENU to start
```

The results of the self-test will show “Passed” or “Failed”. Use the web interface for detailed results of the last self-test.

```
Self Test
Passed
```

USB

```
USB at sda1
SP UFD U3
```

```
USB at sda1
Safe to remove
```

A USB device screen shows both the unique device name and the volume label. Holding the Menu button on a USB device screen will safely eject the device.

```
Data Logger: sda1
SP UFD U3
```

Each USB device also has a screen for use as a Data Logger. Holding the Menu button on this screen will cause the instrument to load a stored configuration file from the USB device and start a measurement. If the stored configuration file specifies, measured data may also be saved to the USB device during a Data Logger measurement. While a Data Logger measurement is in progress, a status screen will be displayed.

```
Meas         10 recs
15% Trigs      1:42m
```

The status screen shows four items: Measurement State, Acquired Records, Completed Triggers, and Trigger Time Remaining.

- Measurement State: This indicates the current state of the measurement’s trigger state machine. Possible values are:
  - Idle: Not running
  - Settle: Waiting for digital filters to settle
  - Start: Waiting for the configured Start event to occur
  - ArmWait: Waiting for the configured Arm event to occur
  - TrigWait: Waiting for the configured Trigger event to occur

  - PreTrig: Waiting for pre-trigger samples to be buffered
  - Meas: Measuring data after a trigger
- Acquired Records: The number of records measured so far this measurement.
- Completed Triggers: If Trigger Count is finite, the percentage of total triggers completed so far. If infinite, the number of triggers completed.
- Trigger Time Remaining: The amount of time remaining until the current trigger's data collection phase is complete. This is only displayed when Measurement State is Meas.

USB MEMORY DEVICES

The EX1403A provides a single USB 2.0 port on its rear panel. Any USB 2.0 or earlier compatible memory device can be attached. A USB hub may also be used to attach many USB memory devices at the same time. For more information related to standalone data logging and USB memory device configuration, please refer to Operation of Data Logger in Section 6

Storage Devices APIs

The Instrument Driver includes a repeated capability exposing all attached USB memory devices at *Storage.Devices*. If any devices are attached or removed after initializing the instrument driver, the *Storage.Devices.Update* method will refresh the list. The *Enabled* parameter of each Storage Device item controls whether data will be saved to the storage device during measurement. The other properties allow querying information about the storage device and configuring the filename and other parameters about how data is saved.

All data stored to USB storage devices is written in either HDF5 or CSV format. The Disk Streaming feature of the Instrument Driver also supports saving data in the same HDF5 format used when writing to USB. Files generated by either method can be read by the same software in the same way.

Stored Configurations

The EX1403A can store its configuration parameters as a JSON file on any attached USB memory device. This configuration file can then be loaded via the instrument driver at a later date, in order to restore the instrument configuration exactly as it was at the time of saving. This configuration file is also used when a Data Logger measurement is performed via the instrument's rear-panel LCD display. Use the Instrument Driver's *Configuration.SaveConfigurationToStorageDevice*, *Configuration.LoadConfigurationFromStorageDevice*, *Configuration.ClearConfigurationFromStorageDevice*, and *Configuration.GetConfigurationDigestFromStorageDevice* APIs to access the configuration file. Each of these APIs takes the Storage Devices repeated capability name as an argument.

Data Logging

The Storage Devices APIs and Stored Configurations features, along with the rear-panel LCD display, enable the EX1403A to act as a stand-alone Data Logger device.

To make use of stand-alone data logging with a USB memory device, the instrument should first be configured using the Soft Front Panel or Instrument Driver for the desired measurement parameters. This includes using the *Storage.Devices* APIs to enabling saving data to the USB device, if desired. The *Configuration.SaveConfigurationToStorageDevice* method should then be called to save the desired measurement configuration to the USB device. The USB device can then be inserted into any EX1403A and used to perform the configured measurement via the rear-panel LCD display. For more information on using the LCD display for Data Logging, see Operation of Data Logger in Section 6.

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SECTION 4

WEB PAGE OPERATION

INTRODUCTION

The EX1403A instrument hosts built-in web page, which allows easy configuration, management and troubleshooting of the device. This internal Soft Front Panel (SFP) is a JavaScript based application which is designed to work within any modern web browser. It can be accessed by typing the instrument IP address or hostname into the browser address bar.

There are several methods to determine the instrument IP address, hostname, and other network settings. The simplest option is to refer to the display on the rear of the device and use the menu button to navigate between pages. If the device display is not physically accessible, the instrument can be discovered using the LXI Discovery tool, National Instruments Measurement and Automation Explorer (MAX), or Keysight (formerly Agilent) Connection Expert (ACE). The EX1403A also supports the mDNS protocol; any tool for Zero Configuration networking, such as Apple ® Bonjour ® or Avahi, can also be used to discover the instrument. For more information on installation of these software utilities, please refer to their respective vendors.

The LXI Discovery tool is a free utility, available for download from the LXI Consortium. It uses the VXI-11 and mDNS protocols to detect any LXI instruments present on the network. Once installed, this software will discover EX1403A instruments, if available, as shown below.

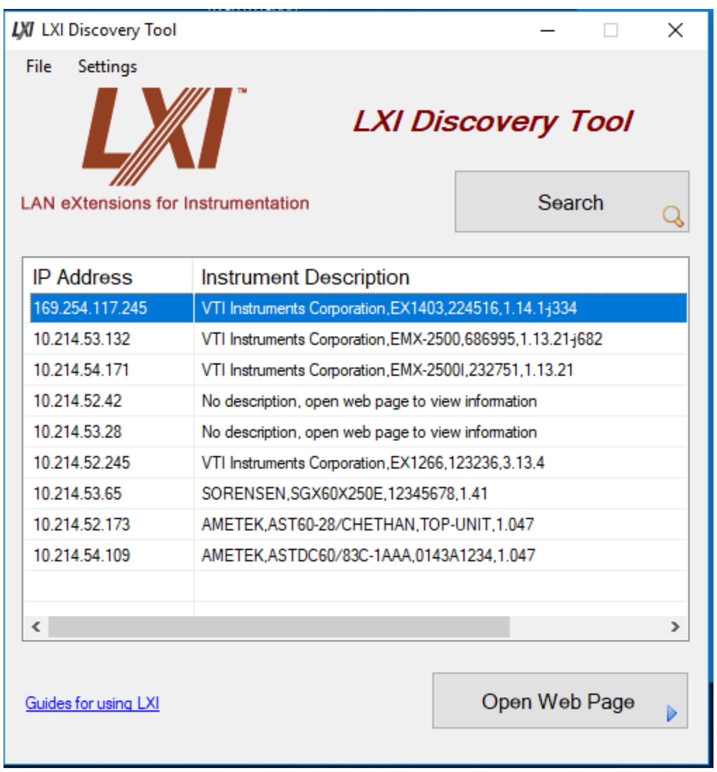


Figure 4-1: LXI Discovery Tool with EX1403A Selected

Alternatively, the EX1403A may also be discovered using Internet Explorer's Bonjour for Windows plug-in. By default, the EX1403A will first attempt to use DHCP to set its IP Address. If DHCP is not available on the network it is connected to, it will instead use Auto IP. Determining the Auto IP address is discussed in the Network Configuration portion of Section 2. Other discovery methods, such as VXI-11, can be used as well.

Common Issues

Certain networking issues may prevent instrument discovery, such as connecting the instrument and host computer to different sub-nets. You may need to contact your network administrator for assistance with these issues. This section describes possible solutions for other common issues.

Multiple Network Ports

Your computer may have multiple physical or virtual network adaptors. For example, a laptop may have wi-fi enabled as well as a wired Ethernet connection to the network containing the LXI device. Some applications also create virtual network adaptors. To resolve this problem, disable all other network adaptors to force the computer to select the network used by the instrument.

Firewall

A firewall may block some or all network traffic between your computer and the LXI device. Contact your network administer for assistance with creating exceptions in the firewall configuration to communication with the instrument. See the table below for a list of ports and protocols typically used by the EX1403A and other LXI devices.

Protocol / Service	Port	Base Protocol	Remarks
mDNS	5353	UDP/TCP	Zero-config protocol for <hostname>.local address resolution; service discovery; Multicast 224.0.0251, FF02::FB
HTTP	80	TCP	Instrument web pages (SFP) and driver communication
ICMPv4		ICMP	Typically enables echo request/respond for ping
ICMPv6		ICMP	Optional - Typically enables echo request/respond for ping, also SLAAC for IPv6 addresses, RDDNS
Arp		Arp	Used to confirm address assignments
DHCPv4	67/68	UDP/TCP	IPv4 address assignment, DNS Server, Dynamic DNS, Gateway
DNS	53	UDP	Naming service
SSH	22	TCP	Bidirectional interactive text oriented communication
RPC port-mapper	111	UDP/TCP	Builds upon Sun-RPC and port-mapper
VXI-11	Varies	TCP	VXI-11 instrument discovery The exact port number varies; query the RPC port-mapper to determine which port is current in use
LXI-eventsvc	5044	UDP/TCP	LXI Event support for instrument triggering; multicast 224.0.23.159, FF02::138. LXI Events can use other ports also, but default port number is 5044
Ptp-event	319	UDP/TCP	LXI Profile IEEE 1588 Precision Time Protocol (PTP); multicast 224.0.1.129, FF02::181
Ptp-general	320	UDP/TCP	LXI Profile IEEE 1588 Precision Time Protocol (PTP); multicast 224.0.1.129, FF02::181
Data stream	9901	TCP	Driver data stream

Table 4-1: Standard Ports, Protocols, and Services

GENERAL WEB PAGE OPERATION

When initial connection is made to the EX1403A, the instrument home page, or Index, appears. This page displays instrument-specific information. This page is accessible from any other instrument page by clicking on the EX1403A web page header. The EX1403A Navigation Menu is displayed on the left-hand side of every internal web page. The entries on the Navigation Menu represent two types of pages:

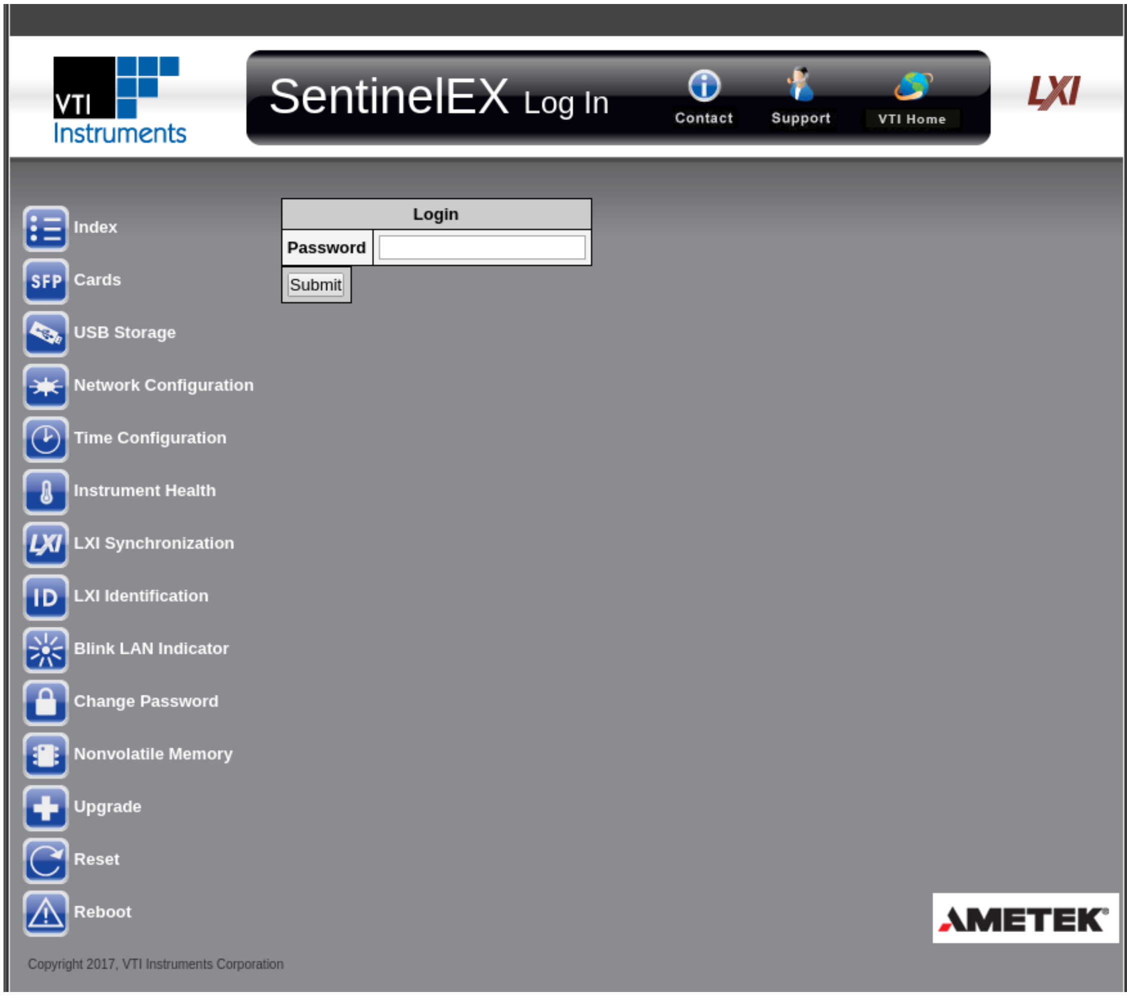
Status: These pages perform no actions and accept no entries. It provides operational status and information only. The Index page is an example of a status page.

Entry: These pages display and accept changes to the configuration of the instrument. The **Network Configuration** page is an example of an entry page. Use of the entry-type web pages in the EX1403A are governed by a common set of operational characteristics:

- Pages initially load with the currently entered selections displayed.
- Each page contains a Submit button to accept newly entered changes. Leaving a page before submitting any changes has the effect of canceling the changes, leaving the instrument in its original state.
- Navigation through a parameter screen is done with the Tab key. The Enter key has the same function as clicking the Submit button and cannot be used for navigation.

LOGIN

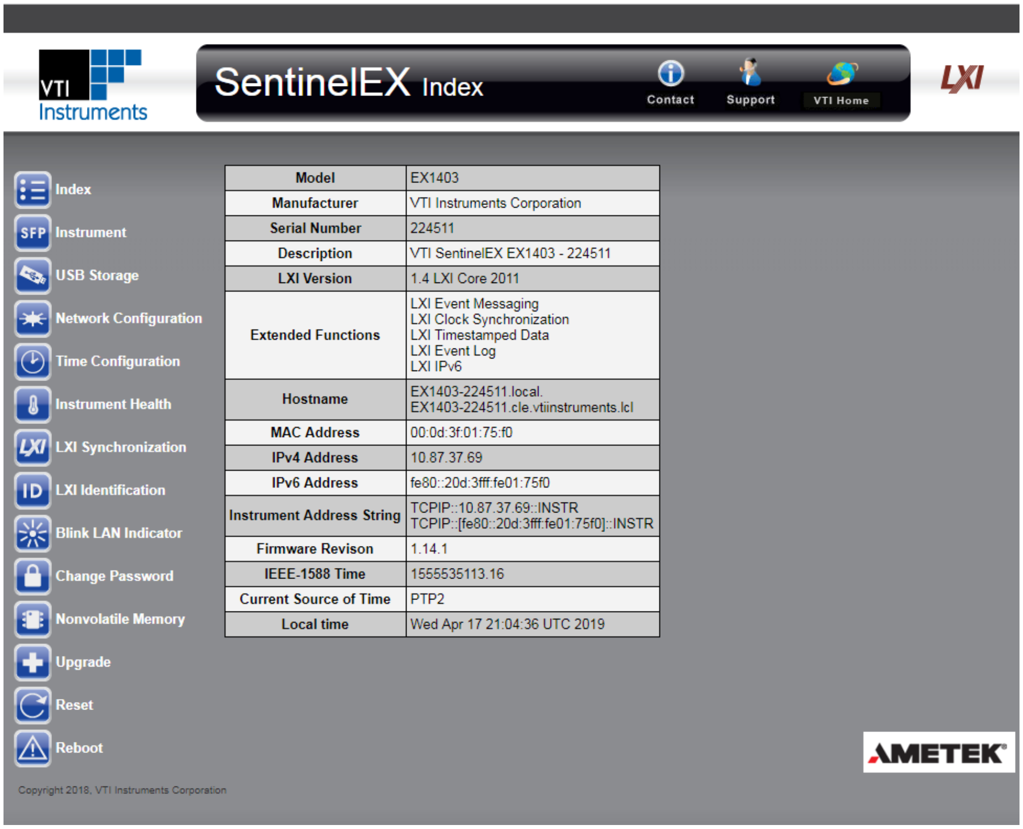
When accessing a page that allows changing configuration parameters of the EX1403A, a password may be required. If so, the Login page will appear.



To log in, simply enter the password in the given text field, and press the Submit button. By default, the EX1403A has no password. To change the password, visit the Change Password page. If the password is unknown, performing a network reset operation will reset the EX1403A to no password.

INDEX

The Index page provides the general information about the EX1403A.



Model	EX1403
Manufacturer	VTI Instruments Corporation
Serial Number	224511
Description	VTI SentinelEX EX1403 - 224511
LXI Version	1.4 LXI Core 2011
Extended Functions	LXI Event Messaging LXI Clock Synchronization LXI Timestamped Data LXI Event Log LXI IPv6
Hostname	EX1403-224511.local. EX1403-224511.cle.vtiinstruments.lcl
MAC Address	00:0d:3f:01:75:f0
IPv4 Address	10.87.37.69
IPv6 Address	fe80::20d:3fff:fe01:75f0
Instrument Address String	TCPIP::10.87.37.69::INSTR TCPIP::[fe80::20d:3fff:fe01:75f0]::INSTR
Firmware Revison	1.14.1
IEEE-1588 Time	1555535113.16
Current Source of Time	PTP2
Local time	Wed Apr 17 21:04:36 UTC 2019

- Model: The model number of the module.
- Manufacturer: The module manufacturer.
- Serial Number: The module's serial number.
- Description: A brief, user-configurable description of the module.
- LXI Version: Indicates which version of the LXI specification the module conforms to.
- Extended Functions: Indicates which LXI Extended functions are supported.
- Hostname: Indicates the Full Qualified Domain Names of the module. The first part of each FQDN is the user-configured hostname.
- MAC Address: Indicates the factory-assigned MAC address of the module.
- IPv4 Address: Indicate the current IPv4 address of the module.
- IPv6 Address: Indicates the current IPv6 address(es) of the module.
- Instrument Address String: Indicates the resource string(s) by which the module can be accessed via its instrument driver.
- Firmware Revision: Indicates the current revision of the module's firmware.
- IEEE-1588 Time: The current IEEE-1588 time.
- Current source of time: Indicates from which source the module is deriving its time.
- Local time: The module's current time, as expressed in the currently configured time zone.

INSTRUMENT

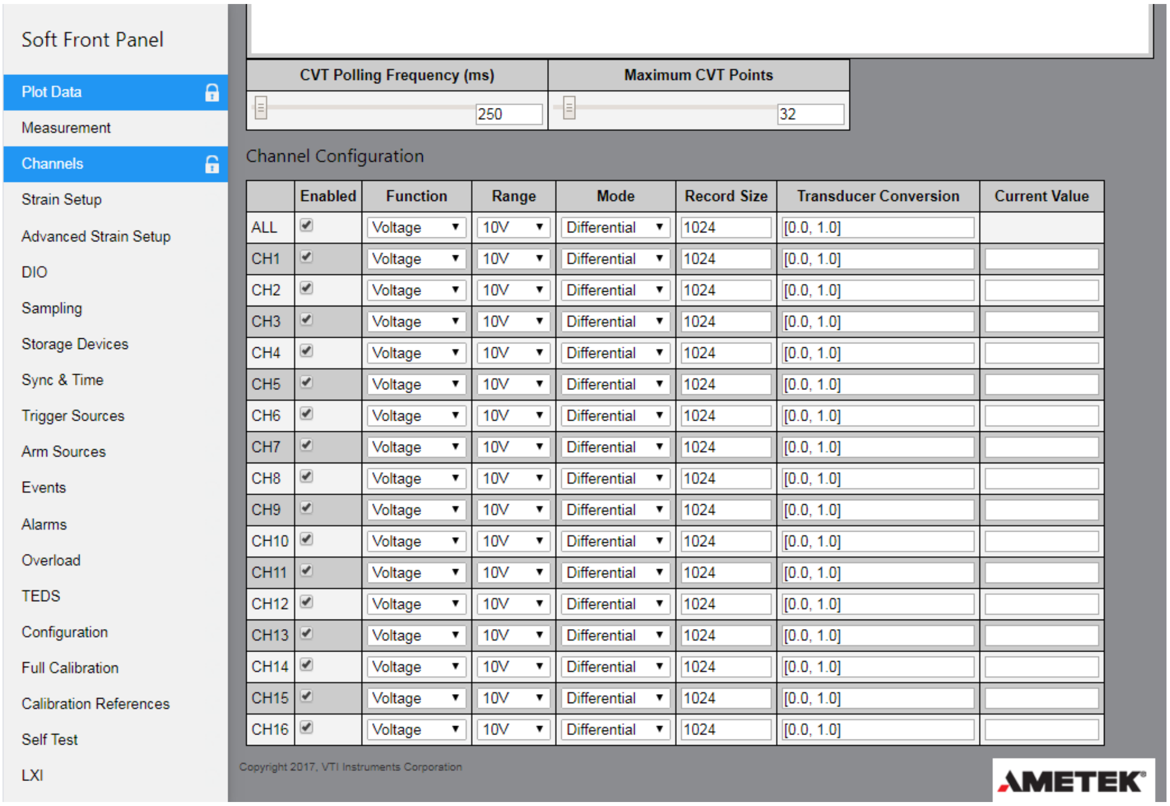
The Instrument page lists all modules of the EX1403A. Because the EX1403A is not a modular instrument, this consists solely of one module: inst0.

The following information is provided for each module:

- **Device**: The bus and slot number of the module. Clicking on the name will launch the instrument control Soft Front Panel.
- **Model**: The model number of the module.
- **Revision**: The firmware version of the module.
- **Serial**: The serial number of the module.
- **Description**: A brief description of the module.
- **Resource**: A resource string that can be used to access the module via its instrument driver.

SOFT FRONT PANEL

The Soft Front Panel popup allows configuration and control of the instrument. It includes access to all firmware APIs exposed by the instrument driver and presents them via an AJAX-enabled web page.



The Soft Front Panel is organized into tabs via a menu of the left-hand side. Each tab contains a set of related options. Clicking a tab will highlight it in the menu and open its contents in the main section of the page. Each tab also has a lock icon. Clicking on the lock will lock the tab, keeping its content visible even when other tabs are opened. Clicking the lock again will unlock the tab, hiding its content. The state of locked and opened tabs is stored in a browser cookie, so that they will persist the next time the SFP is opened in the same browser. As they are not stored in the instrument, connecting from a new PC or browser will not restore the configuration of that previously locked tab.

Most of the Soft Front Panel's fields correspond 1-to-1 with the APIs of the Instrument Driver. Refer to the Driver Structure section for basic information on how to configure the instrument, which is all applicable to the SFP as well.

Changing the value in most of the text entry, drop-down menu, and check box controls of the SFP will cause your browser to send an HTTP PUT request to the instrument, changing the appropriate setting. The browser will then immediately send a GET request for the same property and update the contents of the field with the result. This allows the SFP to keep up to date when the firmware coerces or rejects a value. Some settings can also affect the value of other properties. When this happens, the response to the HTTP PUT will include a cache invalidation header for those properties, prompting the SFP to submit HTTP GET requests for those fields as well.

Some fields in the SFP (such as Overload Status, FIFO Records, and Time) are read-only. These can be polled for updates by clicking on them. The firmware will submit a GET request for any read-only field whenever it is clicked.

To begin a measurement in the SFP, click the "Initiate Measurement" button in the Measurement tab. While the measurement is running, the State, FIFO Records, and Acquired Records fields will be updated up to 4 times per second, showing the state of the measurement. The "Current Value" field of the Channels table will also be updated with the latest measured value from each enabled channel while the measurement is running. If the DIO setting "Reporting Enabled" is checked, then the current input state of the DIO port will also be updated during measurement in the "7" through "0" fields. Note that the data shown under "Current Value" is not necessarily part of a record – it is simply the newest data in the instrument's circular buffer FIFO.

Any records in the instrument FIFO can be downloaded by clicking the "Download CSV" button in the Measurement tab. The "Download Records" field indicates how many records will be removed from the FIFO and converted to CSV format for download. Checking the "All" box causes the SFP to download all available records instead. See section 3 for more details.

Measured data can also be plotted in the Data Plot tab. The following options are available:

- **Plot Type** controls the plot's mode of operation and has two options:
    - **Poll Current Value Table** will plot each new data point that is polled from the Current Value Table in real time, whenever a measurement is running. When this mode is selected, the following parameters are available:
        - **CVT Polling Frequency (ms)** controls the amount of time waited between polling of the instrument's measurement state and Current Value Table. Valid values are from 100 to 10000 ms.
        - **Maximum CVT Points** is the maximum number of Current Value Table points to plot at one time. After this many points are reached, the oldest will be removed from the plot whenever a new one is added. Valid values are from 8 to 512.
    - **Download Records From FIFO** allows records to be downloaded from the instrument's FIFO and plotted directly in the SFP. When this mode is selected, the following buttons are available:
        - **Plot Next FIFO Record** pops a record from the FIFO, downloads it, and adds it to the current plot.
        - **Clear Plotted Records** removes all currently plotted records. Because all data is plotted on a common time-axis, adding data that was acquired far apart in time can create a large gap in the plot. It is recommended to clear the plot before adding more data if the next record is not close in time to the already plotted data.
        - **Save Plotted Records** downloads all currently plotted data in CSV format.
- **Draw Points** controls whether a marker is drawn on each plotted data point, in addition to the line. Turning this on is helpful with small data sets, but with large amounts of data, it can slow down plotting significantly, as well making the plot itself less readable.

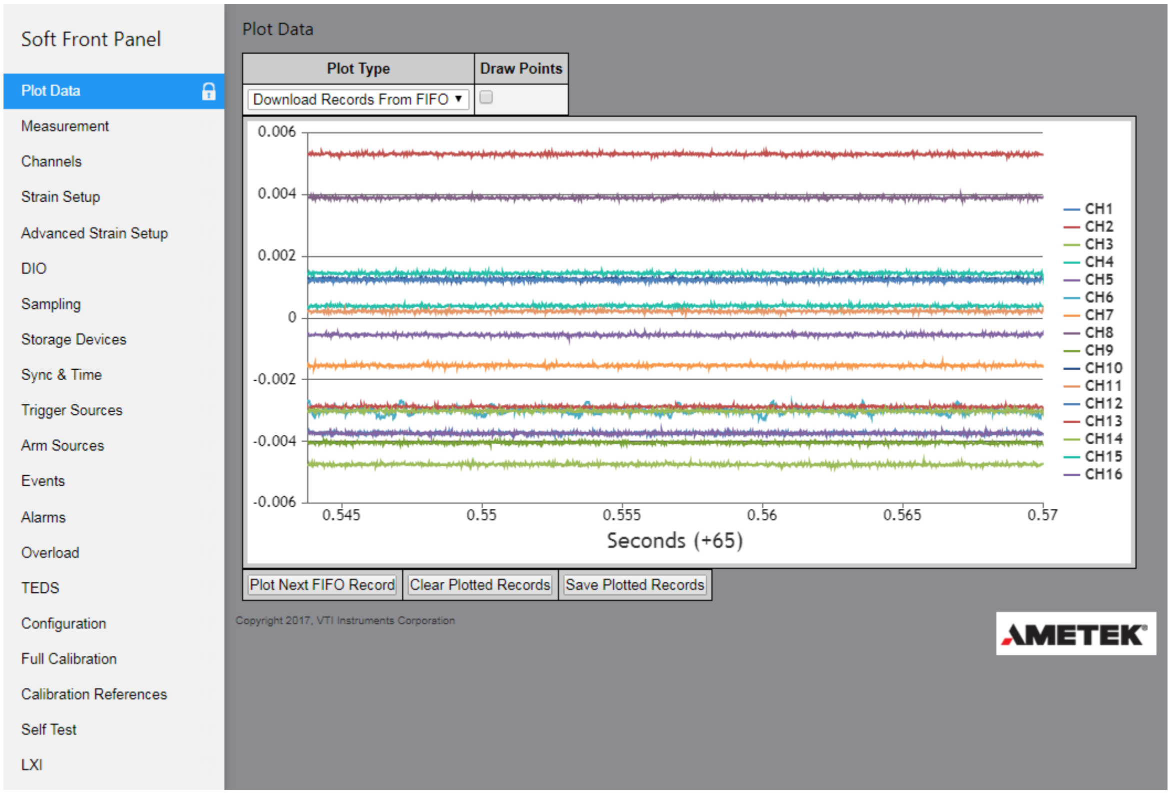
All channel data is plotted via a shared Y-axis, in the selected units for each channel, even if not all channels are configured to use the same units.

The plot's X-axis is always the time axis, in units of seconds. The values on the axis will always be offset by the seconds portion of the first plotted point's time value after clearing the plot (FIFO mode) or starting a new measurement (CVT mode). The offset value will be displayed next to the X-axis label. For instance, if the timestamp of the first plotted value is 34.567, the X-axis label will read "Seconds (+34)" and the first plotted value will appear at 0.567 seconds on the plot. This allows large IEEE 1588 time values to be plotted without crowding the X-axis tick labels.

Hovering the mouse pointer over any plotted point will pop up a message identifying the channel name, as well as both the X- and Y-axis values for the point. X-axis values in this message are the full offset-corrected values.

Hovering the mouse over a channel's name in the legend will cause the data for that channel to be highlighted. Clicking on the channel name will toggle whether that channel's data is visible. The plot's X-axis can be zoomed in by clicking and dragging anywhere in the plot to define the new range of values to display. After doing this, buttons will appear at the top of the plot: Pan, which changes clicking-and-dragging to pan the visible data instead of zooming further; and Reset, which resets to the original zoom level.

DIO data cannot be plotted via the SFP. But, if the DIO Reporting Enabled property is True, any DIO records associated with plotted channel data records will be included in CSV data that is downloaded via the *Save Plotted Records* button.


Soft Front Panel
Plot Data
Measurement
Channels
Strain Setup
Advanced Strain Setup
DIO
Sampling
Storage Devices
Sync & Time
Trigger Sources
Arm Sources
Events
Alarms
Overload
TEDS
Configuration
Full Calibration
Calibration References
Self Test
LXI
Plot Data
Plot Type
Draw Points
Download Records From FIFO
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
0.545
0.55
0.555
0.56
0.565
0.57
Seconds (+65)
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
CH13
CH14
CH15
CH16
Plot Next FIFO Record
Clear Plotted Records
Save Plotted Records
Copyright 2017, VTI Instruments Corporation
AMETEK

USB Storage

The USB Storage page lists all USB storage devices connected to the instrument.

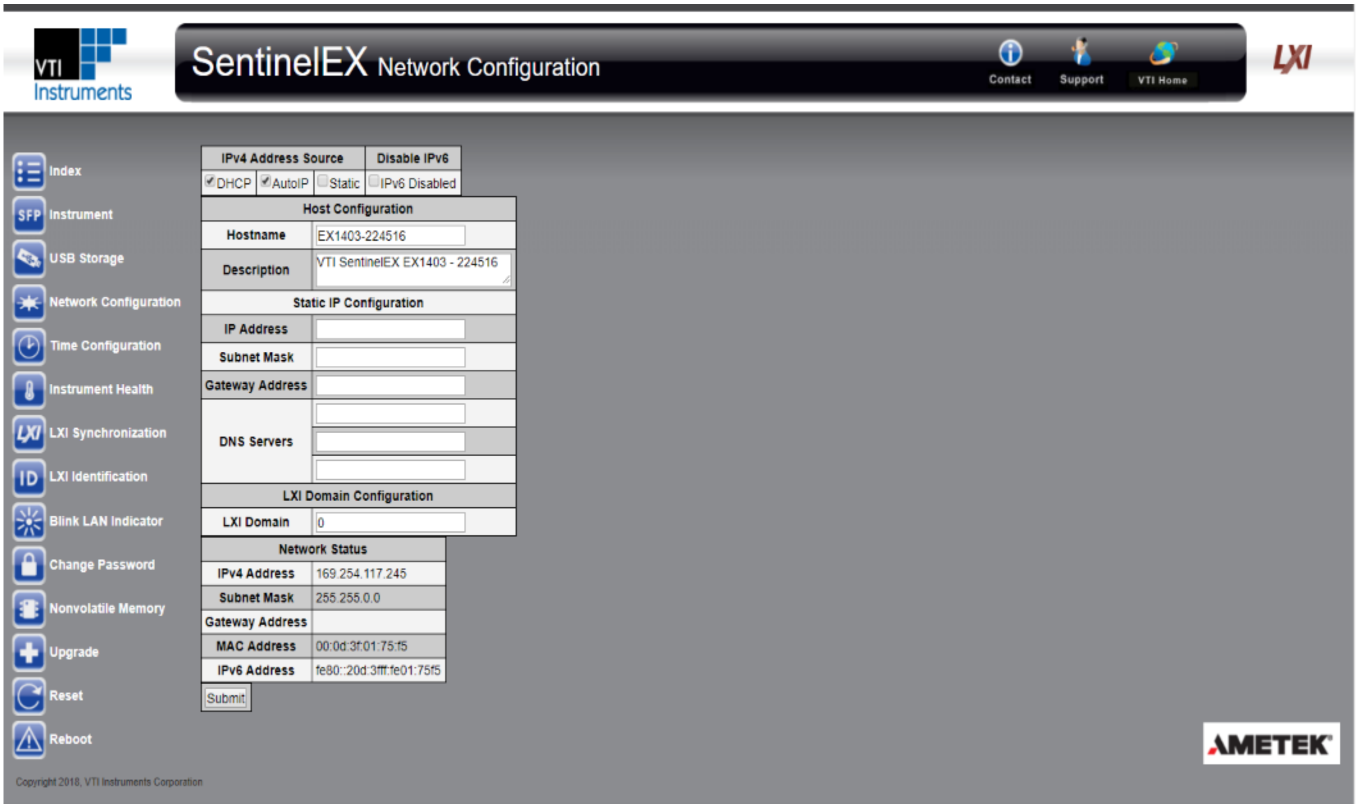
USB storage devices must be properly formatted before connecting them to the EX1403A. The following information is provided for each partition in the USB Storage device:

- **Device Name**: The unique name of the storage device.
- **Label**: The volume label.
- **Size**: The total amount of storage space available.
- **Used**: The amount of space used.
- **Use %**: The percentage of total space used.

Each device also includes an **Eject** link. Clicking this will cause the instrument to disconnect the storage device so that it can be safely removed.

Network Configuration

The Network Configuration Page contains information concerning the configuration of the EX1403A's network interfaces and provides the ability to modify it.

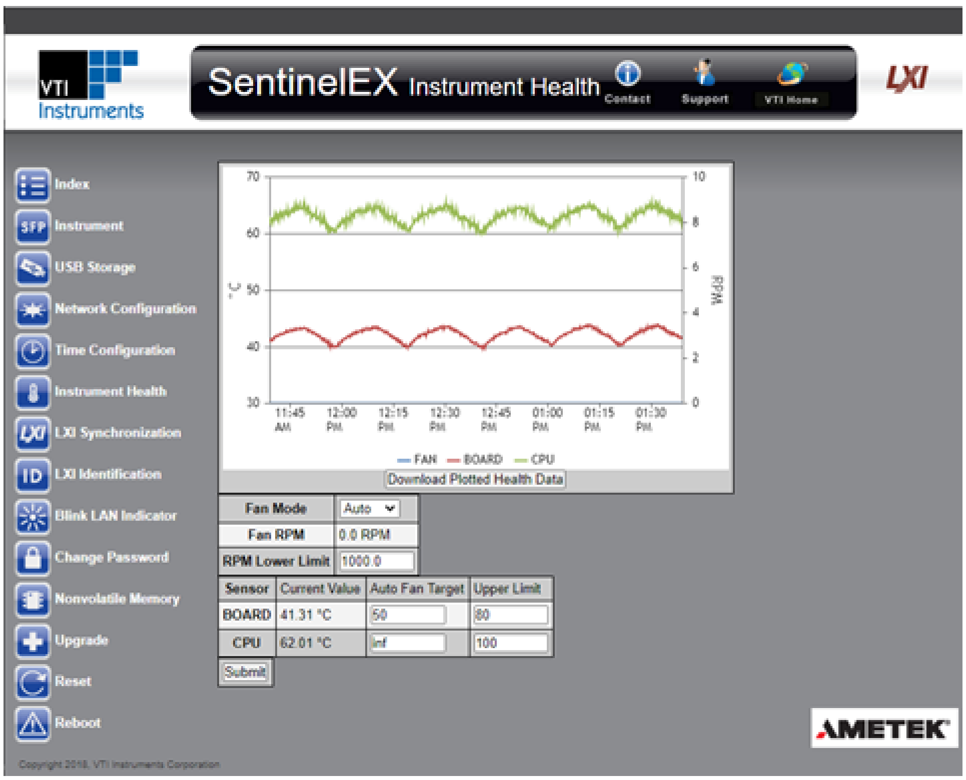


- **IPv4 Address Source**: The IPv4 address for the EX1403A is determined by one of three sequenced mechanisms: **DHCP** → **AutoIP** → **Static**. If an IP address cannot be obtained with the first mechanism, it will progress to the next method. The user also can enable or disable either of these methods by utilizing the adjacent checkboxes.
  - **DHCP**: A protocol that obtains an IP address automatically if the EX1403A is connected to a network with a DHCP server. By default, the EX1403A will attempt to locate a DHCP server. If one is found, the IP address assigned by the DHCP server will be assumed. Otherwise, after a timeout of 20 seconds, the unit will attempt to obtain an IP address by using AutoIP.
  - **AutoIP**: A protocol that automatically creates a link-local IP address based on theEX1403A's MAC address. If the IP address created is not available on a network, another IP will be chosen randomly.
  - **Static**: A user-configured IP address which remains constant. Both DHCP and AutoIP generated IP addresses may change after a reset condition.
- **Disable IPv6**: When checked, IPv6 addressing will be disabled, and the EX1403A will only be accessible via IPv4.
- **Hostname**: Indicates a name which other devices may use to communicate with the EX1403A instead of using its IP address. When mDNS service discovery is used, the host name for the unit will appear. The default hostname is "EX1403A-[serial number]". To reset the hostname to the factory default, delete the current value and submit the page with nothing in this field.
- **Device Description**: This user-configurable field can be used to provide additional information regarding the module (i.e. location, use, etc.). This is visible on the **Index** page without the need for a password. If set, this description will be used as the Service Name for mDNS service discover instead of the hostname above. To reset the description to the factory default, delete the current value and submit the page with nothing in this field.

- **Static IP Configuration**: This configuration section is used to create a Static IP address.
  - **IP Address**: The user-configured IP address is entered into this text field.
  - **Subnet Mask**: Defines the range of IP addresses the EX1403A will attempt to connect to directly (255.255.255.0 means match all but the last number, etc.).
  - **Gateway Address**: The IP address of a server that EX1403A can use to contact IP addresses external to its network.
  - **DNS Servers**: This field is used to provide the IP Addresses of servers that the EX1403A module may use to look up hostnames (e.g. www.powerandtest.com).
- **Network Status:** Indicates the current network settings for the EX1403A's IPv4 Address, Subnet Mask, Gateway Address, MAC Address, and IPv6 Address.

INSTRUMENT HEALTH

The Instrument Health Page contains information concerning the EX1403A's board sensors and fan controls.



- Health Data Plot: This plot shows up to the last 2 hours of periodic measurements of the Fan RPM and Temperature sensors. The temperature axis is displayed on the left-hand side of the plot, and the RPM axis is on the right.
- Download Plotted Health Data: This button downloads a CSV-formatted file containing all the measurements plotted in the Health Data Plot.
- Fan Mode:
  - **Off**: The fan will be OFF.
  - **High**: The fan will be ON at maximum speed.
  - **Auto**: The fan will turn ON whenever any of the temperature sensors' Current Value is above its **Auto Fan Target**. The fan will remain ON until each sensor drops to at least 1°C below its target temperature.
- Fan RPM: The value of the fan speed sensor at the time the page was loaded.
- RPM Lower Limit: If the fan is turned on (either because fan mode is High, or is Auto and one or more temperature sensors are above their target value), and the RPM sensor value is below the value of this setting, the EX1403A will broadcast an LXI LAN Event error packet, and any attempt to start a new

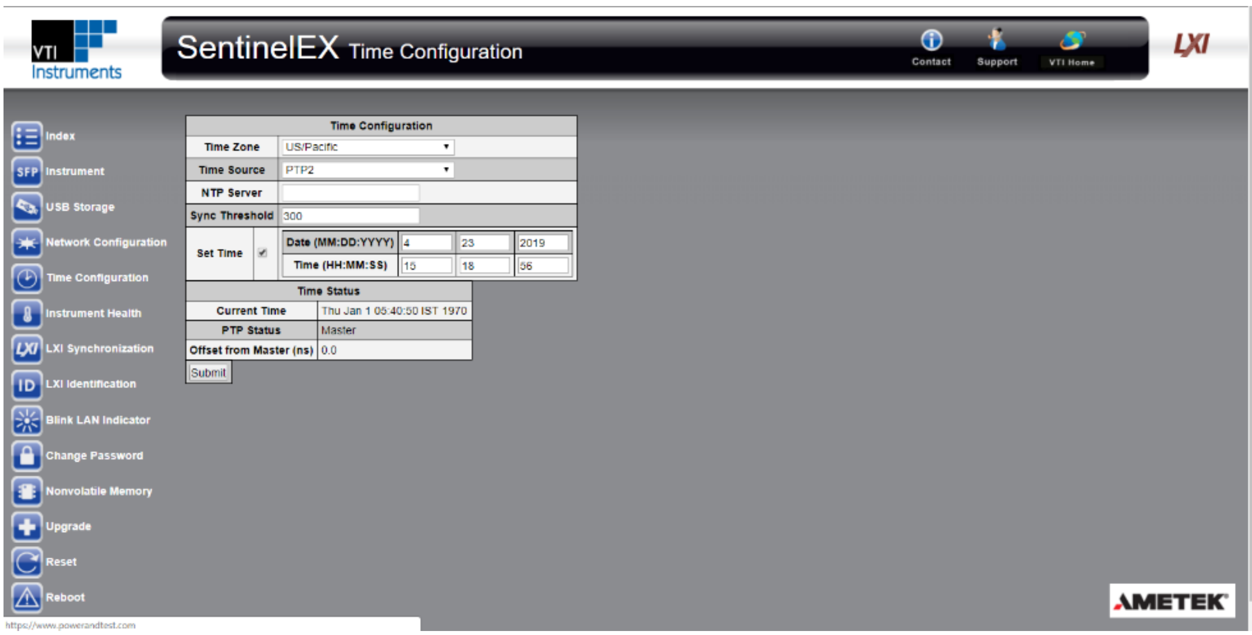
measurement sequence will fail.**Temperature Sensors**: This table lists all of the available temperature sensors in the instrument, along with their **Current Value** and **Auto Fan Target**.

  - **BOARD**: This temperature sensor is located in the digital section near the rear of the instrument, directly attached to the main circuit board.
  - **CPU**: This is the embedded temperature sensor in the CPU die.

- Temperature Sensor Columns:
  - Current Value: The value of the temperature sensor at the time the page was loaded.
  - Auto Fan Target: If the Fan Mode is set to Auto, the fan will be turned on whenever the sensor's current temperature exceeds this value. This can be set to "inf" to indicate infinity, and therefore disable automatic fan control for this sensor only.
  - Upper Limit: If the current value of the temperature sensor exceeds this setting, the EX1403A will broadcast an LXI LAN Event error packet, and any attempt to start a new measurement sequence will fail. This can be set to "inf" to indicate infinity, and therefore disable this check for this sensor only.

TIME CONFIGURATION

The Time Configuration Page contains information concerning the configuration of the EX1403A's source of time and provides the ability to modify it.



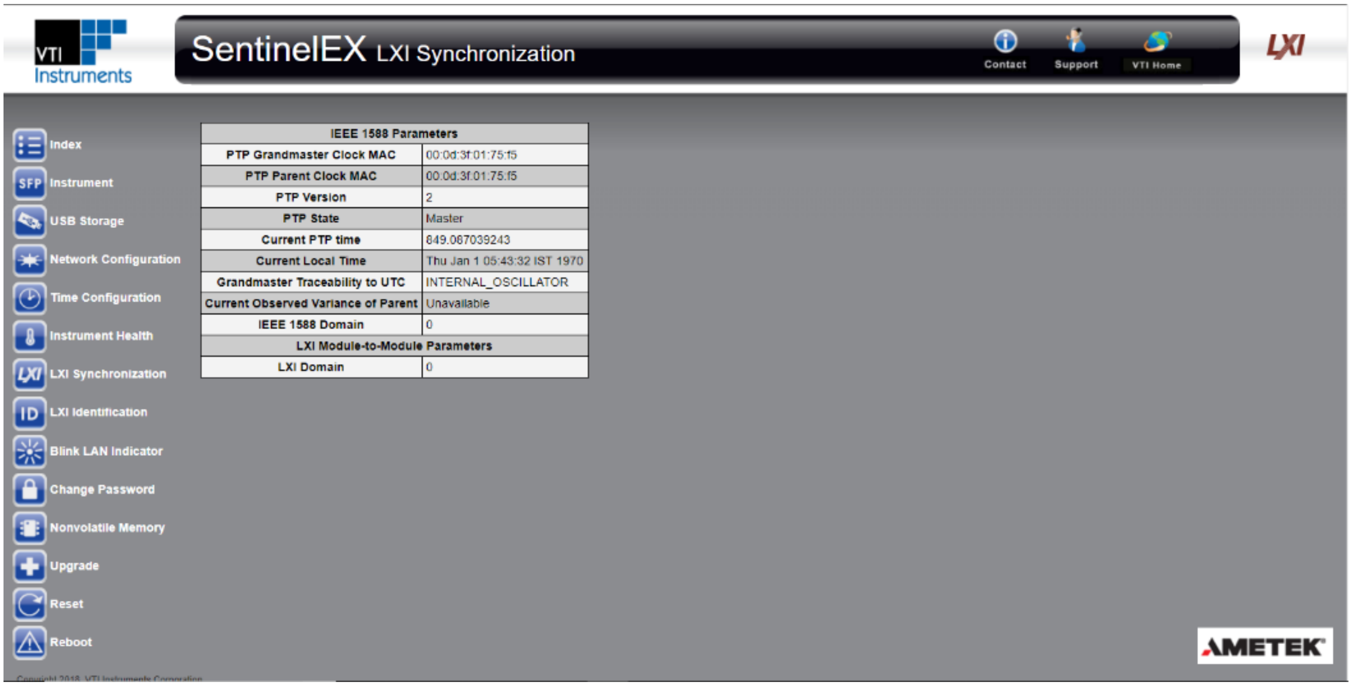
- **Time Configuration**:
  - **Time Zone**: Allows the user to select the time zone for displaying the current local time.
  - **Time Source**: Selects the method to use for setting the EX1403A's time.
    - **PTP2**: Precision Time Protocol Version 2 (IEEE 1588-2008) will be used to synchronize the EX1403A's time with a master clock on the network, or to act as master clock, based on the IEEE 1588 Best Master Clock algorithm.
    - **NTP**: Network Time Protocol will be used to synchronize the EX1403A's time to a remote server, which is specified in the **NTP Server** field below.
    - **Manual**: The time will be set manually by the user via the **Set Time** option below.
  - **NTP Server**: The IP Address or hostname of the server from which to derive time when the **NTP** option is selected. If this is left blank, one of the following values will be used by instead:
    - If the EX1403A is configured for DHCP, and if the DHCP server supplies the address of an NTP server, that will be used.

        - Otherwise, the default value of pool.ntp.org will be used.
    - **Set Time**: Checking the **Set Time** box causes the **Date** and **Time** fields to appear. They will be automatically populated with the current time of the user's PC. When using the **Manual** option, this sets the EX1403A's current date and time. When using the **PTP2** option, this causes a message to be sent to the current master clock, requesting that it set its time.
- **Time Status**:
    - **Current Time**: The current date and time of the EX1403A, translated to the UTC time-base and the selected time zone.
    - **PTP Status**: The current state of the **PTP2** protocol within the EX1403A.
    - **Offset from Master (ns)**: An estimate of the current error, in nanoseconds, of the EX1403A's time from that of its PTP master.

Note: There is no RTC / non-volatile time source inside the instrument. This means, in the absence of NTP / PTP time servers, the device time has no correlation to the computer clock. In this case, the Time Configuration web page can be used to set the instrument's time manually, or the VTEXPlatform driver's Time.SetSystemTime() function can do the same programmatically.

LXI Synchronization

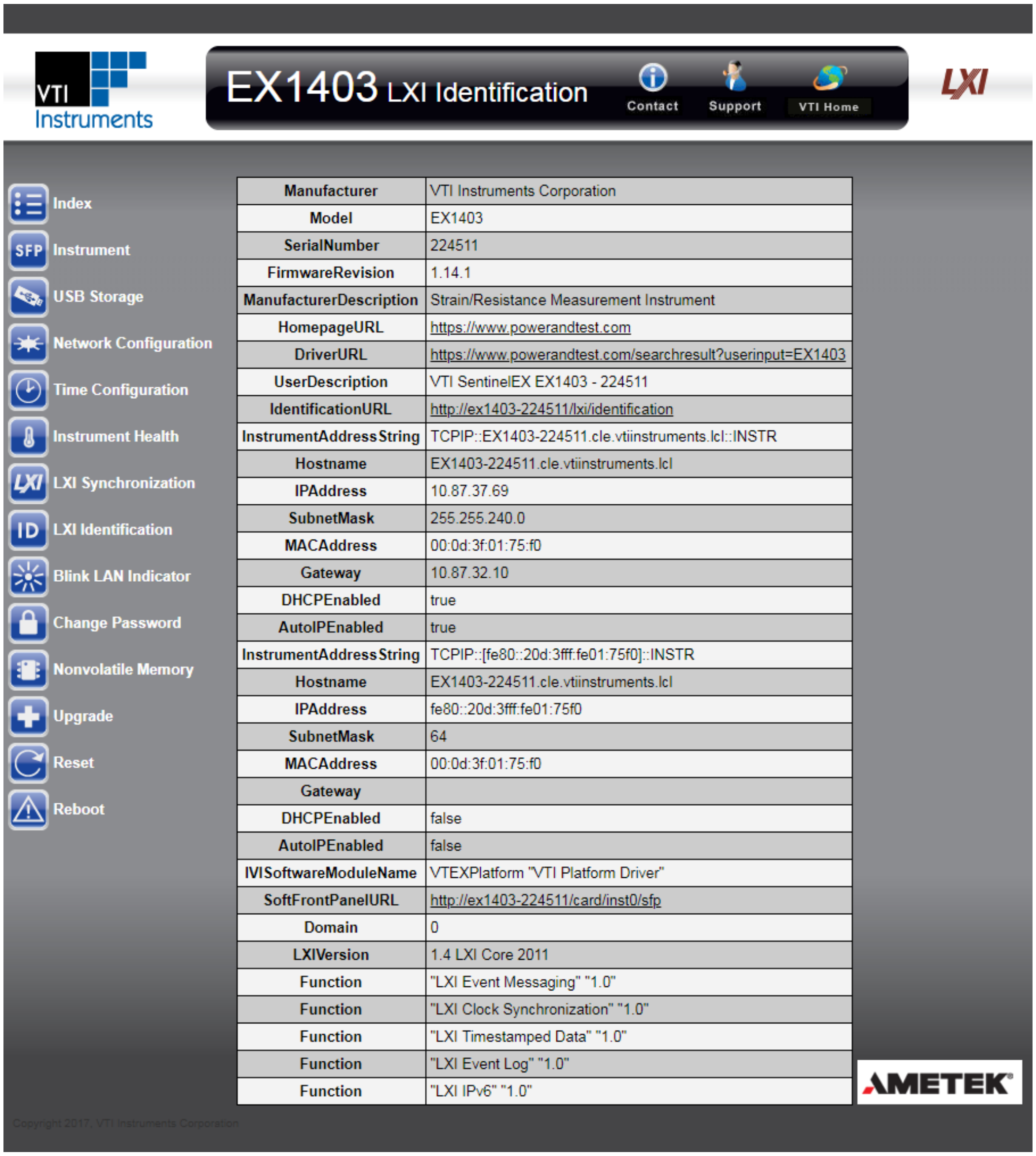
The LXI Synchronization page provides status on the EX1403A's synchronization status.



- **IEEE 1588 Parameters**
  - **PTP Grandmaster Clock MAC**: The MAC address of the device on the network to which all other IEEE 1588 compliant devices are synchronized.
  - **PTP Parent Clock MAC**: The MAC address of the device to which the EX1403A is synchronized. In a hierarchical IEEE 1588 system with boundary clocks, this indicates the MAC address of the parent clock on the local link.
  - **PTP State**: Indicates whether the EX1403A is initializing, faulty, disabled, listening, pre-master, master, passive, uncalibrated, or slave.
  - **Current PTP Time**: The current time on the EX1403A, expressed as the number of seconds since midnight January 1, 1970 TAI.
  - **Current Local Time**: The current date and time of the EX1403A, translated to the UTC time-base and the selected time zone.
  - **Grandmaster Traceability to UTC**: Indicates how the grandmaster is synchronized to UTC. The values provide an indicator of how closely synchronized the grandmaster is to UTC time.
  - **Current Observed Variance of Parent**: This function is not supported by the EX1403A.
  - **IEEE 1588 Domain**: The instrument's PTP domain. Typically, this indicator is 0.
- **LXI Module to Module Parameters**
  - **LXI Domain**: An 8-bit number, 0 to 255, which indicates the domain the EX1403A is using for LAN Events. All events sent by this device will include this number. Likewise, the device will only accept events that include the same LXI Domain number.

LXI IDENTIFICATION

The LXI Identification page is a XML document providing identifying information on the EX1403A.



Manufacturer	VTI Instruments Corporation
Model	EX1403
SerialNumber	224511
FirmwareRevision	1.14.1
ManufacturerDescription	Strain/Resistance Measurement Instrument
HomepageURL	https://www.powerandtest.com
DriverURL	https://www.powerandtest.com/searchresult?userinput=EX1403
UserDescription	VTI SentinelEX EX1403 - 224511
IdentificationURL	http://ex1403-224511/lxi/identification
InstrumentAddressString	TCPIP::EX1403-224511.cle.vtiinstruments.lcl::INSTR
Hostname	EX1403-224511.cle.vtiinstruments.lcl
IPAddress	10.87.37.69
SubnetMask	255.255.240.0
MACAddress	00:0d:3f:01:75:f0
Gateway	10.87.32.10
DHCPEnabled	true
AutoIPEnabled	true
InstrumentAddressString	TCPIP::[fe80::20d:3fff:fe01:75f0]::INSTR
Hostname	EX1403-224511.cle.vtiinstruments.lcl
IPAddress	fe80::20d:3fff:fe01:75f0
SubnetMask	64
MACAddress	00:0d:3f:01:75:f0
Gateway	
DHCPEnabled	false
AutoIPEnabled	false
IVISoftwareModuleName	VTEXPlatform "VTI Platform Driver"
SoftFrontPanelURL	http://ex1403-224511/card/inst0/sfp
Domain	0
LXIVersion	1.4 LXI Core 2011
Function	"LXI Event Messaging" "1.0"
Function	"LXI Clock Synchronization" "1.0"
Function	"LXI Timestamped Data" "1.0"
Function	"LXI Event Log" "1.0"
Function	"LXI IPv6" "1.0"

- **Manufacturer**: The module manufacturer.
- **Model**: The model number of the module.
- **SerialNumber**: The module's serial number.
- **FirmwareRevision**: Indicates the current revision of the module's firmware.
- **ManufacturerDescription**: A brief description of the module.
- **HomepageURL**: The address of the manufacturer home page.
- **UserDescription**: The user-configurable description field.
- **IdentificationURL**: The canonical URL of this document.
- **Network Interface Information**: The following fields will be repeated once for each network interface present in the module:
    - **InstrumentAddressString**: Indicates the resource string by which the module can be accessed via its instrument driver.

- **Hostname**: Indicates the Full Qualified Domain Name of the module. The first part of the FQDN is the user-configured hostname.
- **IP Address**: Indicate the current IP address of the module.
- **SubnetMask**: Indicates the range of IP addresses the EX1403A will attempt to connect to directly.
- **MAC Address**: Indicates the factory-assigned MAC address of the module.
- **Gateway**: The IP address of a server that EX1403A can use to contact IP addresses external to its network.
- **DHCPEnabled**: Indicates whether DHCP is enabled on the interface.
- **AutoIPEnabled**: Indicates whether AutoIP is enabled on the interface.

- **IVISoftwareModuleName**: Indicates the name and description of an IVI-compliant instrument driver that can be used to control the instrument.
- **Domain**: The LXI LAN Event Domain number, 0-255.
- **LXIVersion**: Indicates which version of the LXI specification the module conforms to.
- **Function**: Indicates an LXI Extended Function, and its version, that is supported by the module.

BLINK LAN INDICATOR

The Blink LAN Indicator page allows identification of the device being accessed by causing its LAN LED to blink. This is helpful when there are multiple instruments present in your system, and you need to identify a specific device by its IP address.

- **Turn On**: Cause the EX1403A's LAN LED to blink.
- **Turn Off**: Cause the EX1403A's LAN LED to stop blinking.

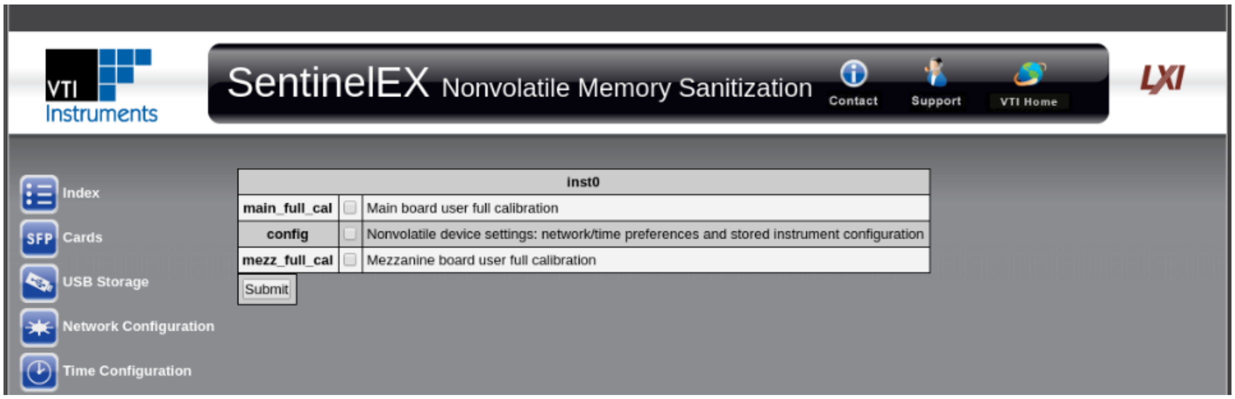
CHANGE PASSWORD

The Change Password page allows the password to be updated.

- **Password**: Set a new password to control access to configuring the EX1403A. Setting an empty password disables password requirements.

NONVOLATILE MEMORY

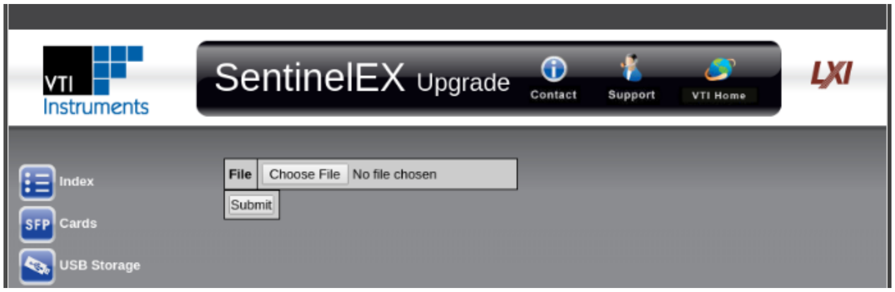
The Nonvolatile Memory web page provides the ability to securely erase the contents of the EX1403A's user-writable memory devices.



- **config**: Securely erases the instrument configuration partition of the main instrument flash. This includes all settings that can be configured through the instrument web page and any stored instrument configurations saved via the instrument driver of Soft Front Panel.
- **main_full_cal**: Securely erases the user full calibration portion of the main board's calibration and identification EEPROM. This contains all the user-supplied calibration information for CH1-8. The factory-supplied full calibration will not be affected.
- **mezz_full_cal**: Securely erases the user full calibration portion of the mezzanine board's calibration and identification EEPROM. This contains all the user-supplied calibration information for CH9-16. The factory-supplied full calibration will not be affected.

UPGRADE

The Upgrade web page provides the ability to upgrade the firmware of the EX1403A. Upgrade files are available from the *VTI Instruments User's Manuals and Drivers CD*, or from the VTI Instruments web site, at https://www.powerandtest.com/.



- **File**: Choose an upgrade file.

RESET

The Reset web page allows the EX1403A to be returned to power-on default settings. This operation is faster than a reboot but does not load new firmware.

- **Reset**: Click this button to reset the EX1403A to power-on defaults.

REBOOT

The Reboot web page allows the EX1403A to reboot. This operation has the same effect as power-cycling the unit – it will re-load firmware from nonvolatile memory and return to power-on defaults.

- **Reboot Device**: Click this button to reboot the EX1403A.

SECTION 5

INSTRUMENT DRIVERS

OVERVIEW

Three drivers, VTEXDigitizer, VTEXDsa, and VTEXPlatform (or libDigitizer, libDsa, and libPlatform, respectively, for Linux), are used to program the EX1403A instruments. The “Digitizer” drivers are common drivers used by all EX Series and EMX Series digitizer devices provided by VTI Instruments. For a simple data acquisition application, the “Digitizer” driver may be the only driver the user needs to use. The “DSA” driver is essentially a super set of the “Digitizer” driver. In addition to the data acquisition functionalities in the “Digitizer” driver, the “DSA” driver also supports the EMX-1434’s signal output and tachometer input capabilities. The “Platform” driver is used to configure the EX1403A’s LXI device specific features, as per IVILXISync API guidelines.

IVI DRIVERS

The IVI Foundation defines IVI driver specifications. IVI specification information is available at the IVI Foundation website, www.ivifoundation.org. The IVI-3.2 Inherent Capability Specification defines a common set of basic functionalities that all IVI driver must support. This ensures that users can perform basic operations and identify its capability for any IVI driver using the exact same API functions. The IVI drivers are implemented using a common code provided by the IVI Foundation in order to guarantee this consistent behavior. This common code is called the IVI Shared Components. The IVI Shared Components must be installed separately prior to any IVI drivers from VTI. The shared components installer is available for download from the IVI Foundation website.

The IVI Foundation specifies that the IVI driver be based on Microsoft Component Object Model, called IVI-COM and an IVI driver using standard C language API, called IVI-C. For those who develop applications in Windows .NET languages, such as C#, VB.NET, or other Object Oriented Language, such as C++, IVI-COM gives APIs logically organized by interfaces. IVI-C gives more traditional C language functions.

While VTI’s IVI drivers are architected based on IVI-COM, the driver installer also installs a wrapper library that exposes IVI-C functions so that the user can use develop in both types of environment.

Header and Library Files

The IVI driver specification defines the install directory structure and software components to be installed. For 32-bit Windows systems, the root of install directory is `C:\Program Files\IVI Foundation\IVI`. For 64-bit Windows systems, the 32-bit driver is installed at `C:\Program Files (x86)\IVI Foundation\IVI` and the 64-bit driver is installed at `C:\Program Files\IVI Foundation\IVI`. Driver header files and library files are installed in several sub directories. The **Bin** subdirectory contains IVI-COM and IVI-C driver DLL files. The **Component** subdirectory contains IVI-COM and IVI-C shared components files. The **Drivers** subdirectory contains the driver specific sub directories. The driver’s online help files and example programs are installed here. The **Include** subdirectory contains header files. The **Lib** subdirectory contains 32-bit import library files. The **Lib_x64** subdirectory contains 64-bit import library files.

DRIVERS FOR LINUX OS

In addition to the IVI drivers for Windows OS, C++ libraries are provided for the Linux operating system. The Linux drivers are supported on distributions running Linux kernel version 2.6.32 or later. In addition, the Linux drivers require GCC version 4.4 or later and glibc 2.12 or later. The driver for Linux organizes and names each C++

class and members consistent to the IVI-COM driver. The driver description in this manual applies to both IVI driver and the library for Linux OS.

The Linux drivers are supplied as RPM packages which are supported by a wide variety of distributions. In distributions which natively support RPM packages, such as Red Hat Enterprise Linux, Fedora Linux, or CentOS, the driver packages can be installed by running the command:

```
rpm –Uvh packagename.rpm
```

There are many other popular Linux distributions which do not natively support RPM packages, but instead use third-party tools to install them. Debian and Ubuntu Linux are both very popular, but do not support RPM packages out of the box. To use these packages on these systems, 'alien' is recommended which should be available in the package repository for these distributions. To install the drivers using alien, run the command:

```
alien –i packagename.rpm
```

Currently, there are both 32- and 64-bit driver packages for libDigitizer, libDsa, and libPlatform. There is also a package which installs common libraries and dependencies used by all drivers, libCommon. The appropriate libCommon package (32-bit or 64-bit) must be installed before installing any of the other driver packages. The release notes for the libCommon package include information on the exact compiler version used for a release.

Header and Library Files

`/opt/vti/include` sub directory contains header files.

`/opt/vti/lib` sub directory contains driver shared object files.

`/opt/vti/share/doc` sub directory contains release notes, driver online help and example programs

BUILDING AND RUNNING EXAMPLE PROGRAMS

Windows Examples

The instrument drivers come with example programs that the user can build and execute. Example programs are in C++ and C# (Windows only) programming language. They are installed in the *Examples* sub-folder under the standard IVI driver installation folder, which is usually found at *C:\Program Files (x86)\IVI Foundation\IVI\Drivers\VTEXDigitizer\Examples* or *C:\Program Files\IVI Foundation\IVI\Drivers\VTEXDigitizer\Examples*. A link to the example programs can also be found in the Start Menu.

Linux Examples

Linux examples are stored at */opt/vti/share/doc/digitizer/examples/*. To build them, copy that folder to a writable location, change directory to the examples folder and run *make*.

COMPATIBILITY

DRIVER AND FIRMWARE REVISIONS

The instrument driver and firmware have three revision fields: <Major>, <Minor>, and <Build>. For the firmware installed on the instrument to be compatible with the driver being used, the <Major> version number must be equal and the <Minor> version must be equal or newer than the driver. Otherwise, the firmware needs to be updated. It is recommended to use the same <Major> and <Minor> version pair, if possible.

DRIVER API AND INSTRUMENTS

The Digitizer driver is designed to work with many digitizer products from VTI Instruments. Not all API functions defined in the driver apply to every digitizer product, since each model has a unique feature set. Calling unsupported API functions will result in a property not supported or method not supported error. See the manuals for the other digitizer products for more details on their supported features.

Digitizer APIs	EX1403A Support
Alarms	Supported
Arm	Supported RPM (DSA), Pattern (DSA) not supported by digitizer devices
Calibration	Supported Self-calibration not supported
Channels	Supported AutoCal, AutoRange, Filter, Measurement, Temperature, Weighting are not supported Function: Voltage, Strain, Cal, Resistance Coupling: DC Mode: Differential, SingleEnded
Configuration	Supported
Dio	Supported
Events	Supported Pulse not supported
Measurement	Supported DataFormat: EUReal32, VReal32, RawInt32 FIFOMode: Stop only
Sampling (Measurement and Channel interfaces)	Supported Multipass, Oversample not supported Prescaler: must be 1
Platform	Supported
ReferenceOscillator	Supported PXIClk10 not supported
SelfTest	Supported
Start	Supported
Storage Devices	Supported
StreamingData	Supported
Sync	Supported
Temperature	Supported
Time	Supported
Trigger	Supported MaxQueueSize, QueueEnabled not supported

Table 5-1: Supported Functions in Common Digitizer APIs

DRIVER STRUCTURE

MEASUREMENT

This section provides information related to configuring the basic measurement setup and control. The basic measurement configuration and control can be done through the driver's Measurement interface. The Measurement interface configures parameters that are global to entire system, rather than individual channels, or instrument modules when more than one module is included in the driver.

The parameters the user can set using the Measurement interface are:

- Sampling parameters, including ADC sampling rate, digital decimation filters span, and data record size
- Number of data acquisition records at each trigger event
- FIFO mode of operation
- Data format

The Measurement interface can be used to query the current measurement state information:

- Measurement state machine state
- Total number of records available in FIFO

Methods to control measurement, such as:

- Initiating measurement
- Aborting measurement
- Retrieving acquired data

CHANNELS AND CHANNEL GROUPS

This section provides information related to using channels and channel groups. For more detailed information, see the online help file provided with the Digitizer driver.

The Channels interface contains both channel objects and channel group objects in the same array. A channel object represents an individual analog input channel. A channel group object represents one or more analog input channels as a group. When a driver is initialized or reset, the repeated capability contains the analog channels, one channel group representing all the analog channels, and one or more channel groups representing the analog channels from each digitizer model in the driver session. For example, when there are two EX1403A instruments and one EMX-4350 in a single driver session, the *Channels* interface contains an array totaling 39 channel objects. Those channels are 32 individual EX1403A analog input channels (16 from each EX1403A), four EMX-4350 individual analog input channels, one channel group object that represents all 36 analog input channels, one channel group for all 32 EX1403A inputs, and one channel group for all four EMX-4350 inputs. These channel groups are named "All", "EX1403A", and "EMX-4350".

The channel array is created in ascending slot order for modular instruments (such as the EMX family). The first element in the array is the first analog input of the digitizer card that is installed at the lowest slot in a chassis. When more than one instrument is included in the total system, the channel order is determined by the resource string used in the driver's *Initialize* call.

The individual channel objects are used to configure or query individual input channel properties.

The channel group objects can be used to configure multiple channels to the same value. In general, the user can configure multiple channels faster using a channel group than setting channels individually. Querying the current setting through channel groups works only when all channels are set to the same value.

The channel name is defined as <slot no>!CH<channel no>. For example, 2!CH2 indicates the 2nd channel of a card installed at slot2 of a chassis. The predefined channel group names are "ALL" or an instrument model number such as "EX1403A". Optionally, the user can create new custom channel groups using *AddChannelGroup* method. When more than one instrument are in the session, the channel name of the 2nd instrument adds 100 to the slot number, such as 102!CH2, and 200 for the 3rd instrument, 300 for the 4th, etc. The EX1403A instrument consists of a single digitizer slot called inst0.

The *NumChannels* property gives the total number of individual input channels, while the Count property is the total number of channel or channel group objects in the array.

VOLTAGE CHANNEL CONFIGURATION

When *Function* is set to *Voltage*, the EX1403A's channels can each be configured for *Range*, the maximum voltage that can be measured, and *Mode*, which selects either *SingleEnded* or *Differential* measurement types.

RESISTANCE CHANNEL CONFIGURATION

When *Function* is set to *Resistance*, the EX1403A channels' configuration options are similar to *Voltage* mode, with a few exceptions. The value of the *Mode* property is ignored; all measurements are *Differential*.

When *Strain.ExcitationType* is *Current*, the range *Range* property is in units of Ohms, with supported values equal to each of the supported Voltage ranges divided by each of the supported excitation currents. When *Strain.ExcitationType* is *External*, the range *Range* property is in units of Volts, and the user must configure the externally supplied current via the *Strain.ExcitationLevel* property to ensure proper EU conversion of data into Ohms.

If *Strain.BridgeType* is set to *FourWireOhm*, resistance measurements will use four wire mode. For any other setting of *Strain.BridgeType*, resistance measurements will be performed in two wire mode.

STRAIN CHANNEL CONFIGURATION

When *Function* is set to *Strain*, a wide variety of channel configuration options are available. Like with *Resistance*, the *Mode* property is ignored; all *Strain* measurements are *Differential*. *Strain.ExcitationType* controls the type of excitation applied to the channel – *Voltage*, *Current*, or *External*. If *External* is selected, the instrument turns off its internal excitation supplies, and the user may supply a custom excitation externally. *Current* should only be used when *Strain.BridgeType* is *TwoWireOhm*or *FourWireOhm*. *Voltage* should be used for all other bridge types. *Strain.ExcitationLevel* specifies the value of the excitation. For *Voltage* and *Current*, setting this selects from the internally generated values, and reading it returns the last measured or calibrated value of the current selection. *Strain.MeasureExcitaionLevel()* will cause the instrument to perform an internal measurement of the *Voltage* excitation and is not supported for other types. For *External*, *Strain.ExcitationLevel* allows the user to specify the magnitude of their externally supplied excitation, for use in EU conversions. When *Strain.ExcitationType* is *Current*, the channel *Range* has units of Ohms, and setting it will also select the appropriate value of *Strain.ExcitationLevel*. *Strain.DynamicExcitationEnabled* controls whether the channel's voltage excitation is continuously monitored via internal measurements. A single auxiliary ADC scans through all channels for which this is true at approximately 20 readings per second (thus if all 16 channels are enabled, it will take about 800ms to measure them all once), and applies an exponential filter to the data, weighting the previous result at 0.8.

Strain.BridgeType selects the type of bridge to use, configuring the channel hardware and EU conversion appropriately. For the *TwoWireOhm* and *FourWireOhm* values, the nominal gauge resistance must be specified via the *Strain.OhmGaugeResistance* property.

Strain.ShuntEnabled controls whether the EX1403A will shunt the bridge using the resistor selected by the *Strain.ShuntSource* property. The available resistors on EX1403A are 50kOhm (*InternalCustom1*), 100kOhm (*InternalCustom2*), and *External*, to use the user-supplied resistor connected to the spring terminal blocks labeled Shunt Cal Res A and B. Because only one user-supplied resistor is available for each group of 8 channels, the *External* source can only be enabled on one channel out of each group at a time. *Strain.RemoteShuntEnabled* selects whether the shunt will be applied internally or via the Remote Shunt pins (pins 4&5 of the channel RJ45 connector).

For quarter bridge types, it is not possible to internally shunt the bridge, and so *Strain.RemoteShuntEnabled* must be set to true when shunting channels configured in this mode.

Strain.GaugeFactor specifies the sensitivity of the strain gauge. *StrainUnstrainedVoltage* is the bridge voltage when the gauges are at rest. *Strain.MeasureUnstrainedVoltage()* can be called to cause the firmware to measure this. *Strain.PoissonRatio* represents Poisson's Ratio for use in the EU conversion of bridge types *HalfPoisson*, *FullPoisson*, and *FullBendingPoisson*. *Strain.LeadWireResistance* specifies the resistance of the wiring from the instrument to the gauge. This should always be used in quarter bridge or *TwoWireOhm* modes to compensate for desensitization caused by this wiring resistance. It can also be used with half and full bridge modes if the external excitation sense lines are not utilized to bypass this effect. *Strain.MeasureLeadWireResistance()* can be called to have the EX1403A measure this resistance itself. For *TwoWireOhm* mode, the resistance of the bridge at the time of measurement must be known precisely for this measurement to work; it should be specified before measuring via the *Strain.OhmGaugeResistance* property.

START, ARM, TRIGGER, AND ALARM

The EX1403A implements a sophisticated Arm/Trigger model as show in Figure 5-1. This trigger model conforms to industry stand trigger models defined in the IVI Digitizer specification and IVI LXI Sync specification, with some additional features.

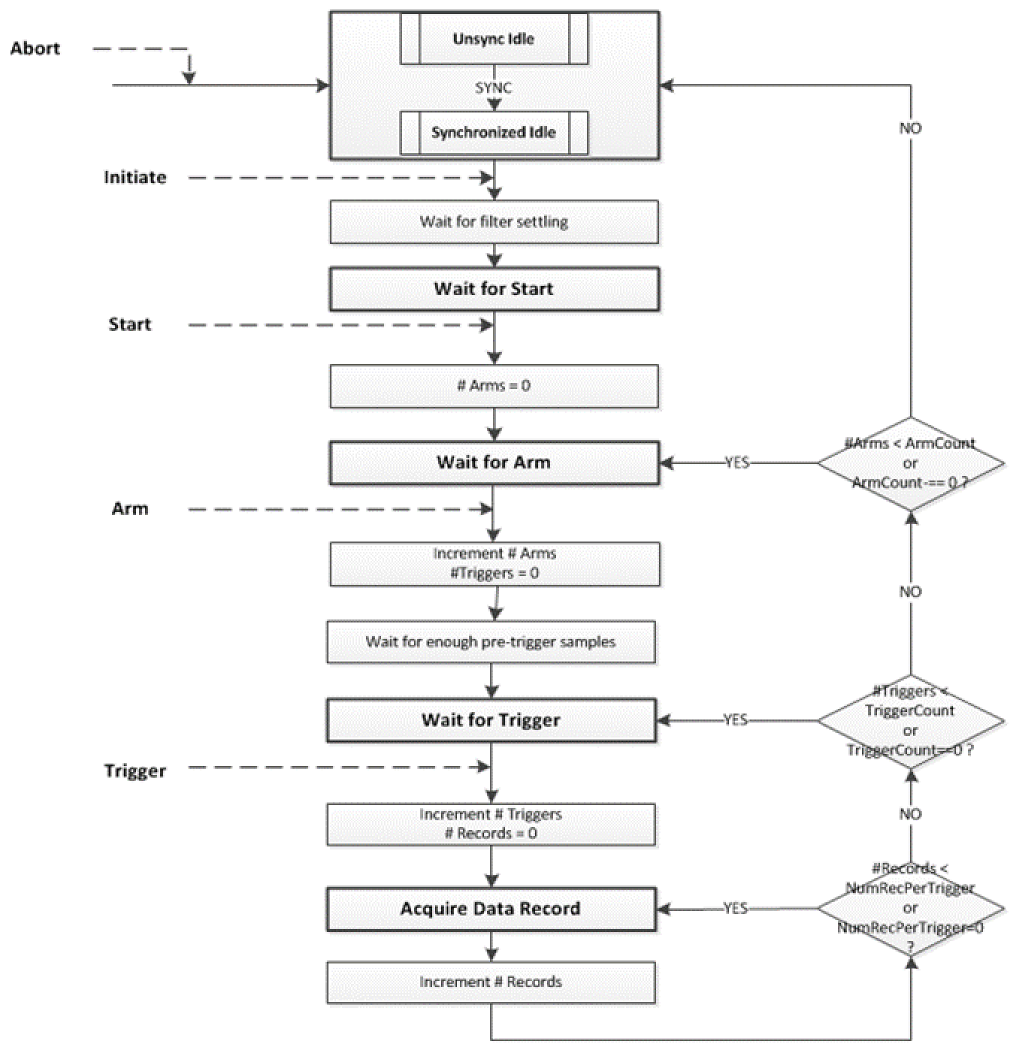


Figure 5-1 Trigger Model

Sync

Sync is an event that synchronizes the entire system. The *Sync* interface is used to configure the synchronization between cards. All cards are simultaneously started by the SYNC signal and then they synchronize the state machine transition with each other through a coordination signal. The *Line* and *CoordinationLine* properties define which PXI trigger lines and/or Alarms to use to send these signals.

Start

Once the measurement is initiated by the Initiate command, the instrument completes all preparation and becomes ready to start taking data immediately. Then the state machine moves to the *Wait for Start* state. The *Start* interface provides methods and properties to advance to the next state. The amount of time it takes to reach to *Wait for Start* after measurement *Initiate* command varies depending on the measurement configuration. For example, it takes longer when the measurement sample rate (or measurement span) is low because the filter settling time is longer. The *Start* interface is useful when the user wants to have the instrument complete all the preparation and hold in that state, so that it can start taking data immediately without any delay.

Arm

The instruments must be armed before triggering data acquisition. The *Arm* interface is used to configure this arming condition. The *Sources* property in the *Arm* interface defines the arming event sources. The default arming source is *Immediate*, which means automatic arming. The *SourceOperator* property allows the user to define an arming condition by logically combining multiple arming sources. The *Delay* property defines amount of time the instrument waits before moving out from *Wait for Arm* state after the defined arming conditions are met. The *ArmCount* property defines how many times the measurement repeats arming and triggering before it completes. The default is once. Setting *ArmCount* to 0 forces the measurement to repeat arm and trigger indefinitely until it is aborted by *Abort* command.

Trigger

Data acquisition begins when a triggering condition is met. The triggering condition is configured using the *Trigger* interface. Similar to Arm interface, the *Sources* property in the *Trigger* interface define the triggering event sources. Trigger sources can be logically combined using *SourceOperator* in the *Trigger* interface. The *Delay* property defines the amount of time between the trigger event and the beginning of the data acquisition. The *Delay* value can be negative indicating pre-trigger data acquisition. In this case, the acquired data block starts earlier than the trigger event. This is achieved by buffering the data in the instrument’s FIFO prior to the trigger event. For more information, see the Data Acquisition section.

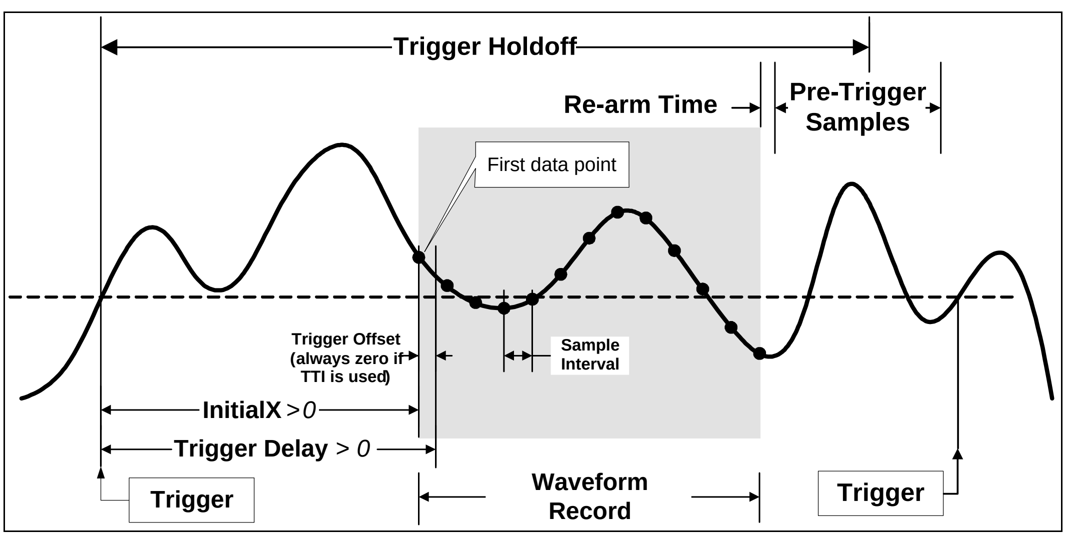


Figure 5-2: Positive Trigger Delay

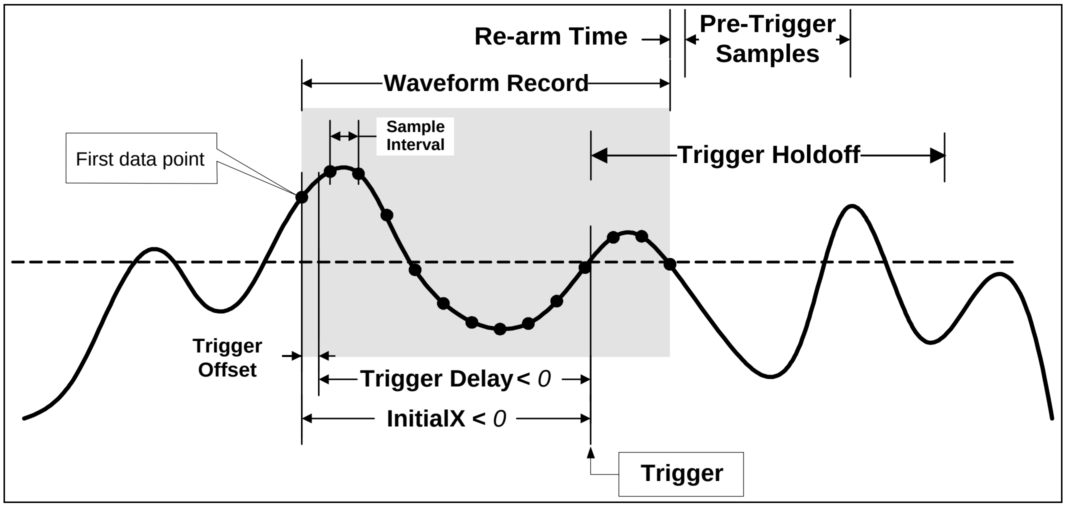


Figure 5-3: Negative Trigger Delay

The *TriggerCount* property defines how many times the trigger events are accepted, and data blocks are acquired. After "*TriggerCount*" triggers are processed, the measurement waits for the next arming condition or finishes. The *Holdoff* time specifies the minimum amount of time the measurement must wait before it can be triggered again once a trigger is detected. Any trigger events that occurred during the *Holdoff* time are ignored. When the specified *Holdoff* time is shorter than one data record period, the two successive data records may be overlapped.

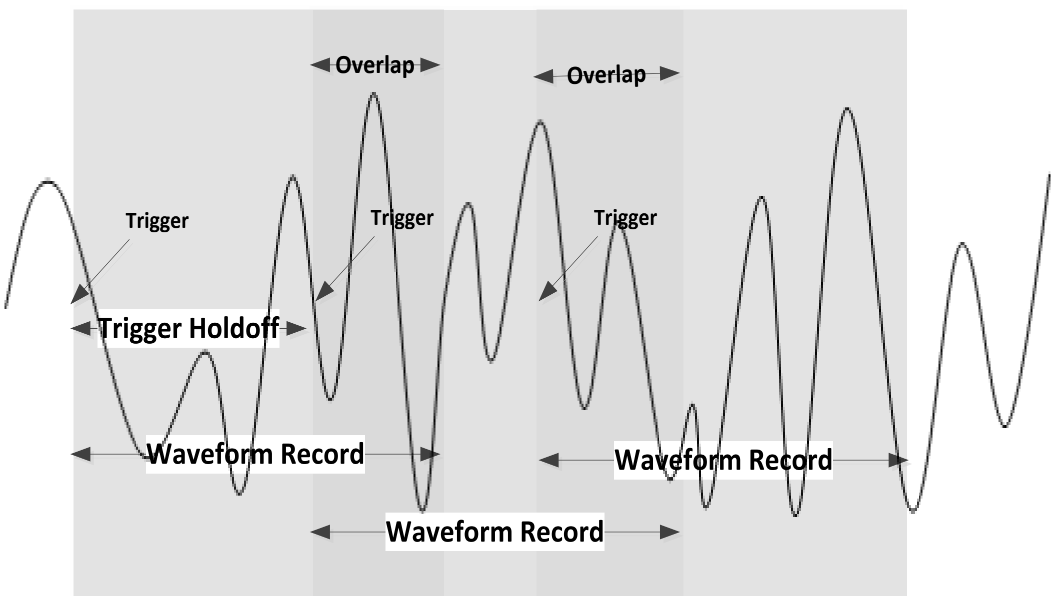


Figure 5-4: Overlapped Data Acquisition

Trigger Holdoff

The ability to configure the TRIG event source to be an external event such as a Digital I/O channel level or a Trigger Bus channel edge is a powerful test feature, allowing measurements to be precisely correlated with external events. External events, however, could nominally be generated at a rate far faster than the EX1403A can completely and correctly execute the DEVICE layer. To prevent the instrument from being overdriven, the trigger model contains an internal holdoff timer. Once the trigger event has been satisfied, this timer disables the recognition of all trigger events for a time period of 1 sample period. Trigger events that occur during this period are ignored, not buffered. This is similar in concept to the fact that, for example, additional ARM events are ignored if the trigger model is not specifically waiting for an ARM event. Due to this action, triggering the EX1403A with a burst of external pulses that exceeds the configured sample rate will result in not only fewer readings than trigger events, but also a reading rate that is potentially far less than the maximum rate.

Consider an example in which the trigger model is set to the following configuration:

Start Source	Immediate
Arm Source	Immediate
Arm Count	1
Arm Delay	0
Trig Source	DIO Channel 0 Positive Edge
Trig Count	100
Trig Delay	0
SampleRate	1000

Once initialized, the EX1403A is driven by a burst of 100 positive edge transitions at a rate of 1.5 kHz. At 1.5 kHz, the time between trigger events is 667 µs. Since this time is less than 1 ms, every other trigger event will be ignored. Consequently, this burst will generate 50 readings at a rate of 750 Hz. Note that the actual reading output rate is far less than the 1 kSa/s maximum rate. To achieve the maximum output rate, the TRIG event source should be set to Immediate.

Start, Trigger and Arm events

There are three events that control the progress through the trigger model: The Start, Arm, and Trigger events. Each of these events can be programmed independently to be activated from any of the External Trigger, Digital I/O port, LAN events, Channel Analog Levels, and LXI alarms. In addition, each event can be programmed to be Immediate, creating a permanent satisfaction of the event monitor. Each event monitor can also be bypassed on command with the issuance of a Software Start, Software Arm, or Software Trigger, as appropriate. The full list of sources includes:

- Digital Sources:
  - Immediate
  - Software
  - ALARM0-1
  - EXT
  - DIO0-7
  - LAN0-7
- Analog Sources:
  - CH1 to CH16

The Start event source can be any one of the Digital sources (except for LAN0-7), and is always a Falling Edge event.

The Arm event source can be any combination of the Digital sources, via either a Boolean AND or a Boolean OR of all enabled sources. Each enabled source can be a High Level, Low Level, Rising Edge, or Falling Edge event.

The Trigger event source can be a combination of either any of the Digital or any of the Analog sources, via either a Boolean AND or a Boolean OR of all enabled sources. Each enabled source can be a High Level, Low Level, Rising Edge, or Falling Edge event. Analog and Digital trigger sources cannot be enabled at the same time.

The Digital I/O port and the External Trigger monitor the digital hardware ports on the rear panel of the instrument. An Arm or Trigger event can be controlled by any combination of the eight channels of each port.

LAN Events are triggered through the eight LAN Event channels via Ethernet packets (UPD/multicast or TCP messages). They are configured in a manner similar to the Digital I/O port. These events can occur in “past time”, “now”, or “future time”. “Past time” events have an IEEE 1588 time that occurred in the past. These will cause data starting from the time indicated in the packet to be marked for retrieval. But, if the instrument was not in the

WaitingForTrigger state at the specified time, the packet will be ignored. "Now" events have a IEEE 1588 time of "0", indicating that the event will occur immediately after it is received. Because they have a time of "0", the event log will only identify when this event was received. "Future time" events have an IEEE 1588 time that has not yet occurred. Because these events occur in the future, they can be prepared for and provide a better response time than either "past" or "now" events.

LXI alarms are specified by IVI 3.15, IVILxiSync specification. The LXI alarm will cause an event based on IEEE 1588 time and always occur at the pre-programmed time. The alarm period can be set for this event as well, allowing the LXI alarm to fire repeatedly at a defined interval.

NOTE:	The extensive flexibility of the trigger model system permits the creation of very specialized trigger conditions, which is a powerful application tool. However, it also permits the creation of trigger conditions that would be very difficult to satisfy in practice. For example, if edge conditions are specified on multiple digital hardware channels, the edges must occur within 25 ns of each other to be recognized as having occurred simultaneously.

Alarms

LXI alarms are a mechanism that generates events at a fixed time interval as specified by IVI 3.15, IVILxiSync specification. When the *Enabled* property is true, the alarm starts at the time specified by *TimeSeconds* and *TimeFraction* and repeats for *RepeatCount* times. The *Period* property defines the interval between the two successive alarm events. Setting the *RepeatCount* property to 0 causes the alarm to continue firing at the specified *Period* until the *Enabled* property is set to false. Setting the *Period* to 0 causes the alarm to fire only once. The alarm properties can only be modified when the alarm is disabled.

As an extension to the LXI alarm capabilities, the EX1403A also supports "now" alarms (similar to "now" LAN events). Setting the *TimeSeconds* and *TimeFraction* properties to 0 causes the alarm to fire as soon as it is enabled.

Alarms can be used as an arm or a trigger event source.

Output Events

The EX1403A also supports several output events. These are trigger output signals that the EX1403A can use to synchronize other instruments to itself. These include the External Trigger, Digital I/O, and LAN Events.

- Output Events
  - EXT
  - DIO0-7
  - LAN0-7

Each output event's logic level can be controlled by one of several event sources. These include static levels, internal trigger state machine events, the state of many of the input trigger sources, and the Overload state of analog channels.

- Static Levels
  - 0
  - 1
- Trigger State Machine States
  - Operation Complete
  - Waiting For Start
  - Waiting For Trigger
  - Waiting For Arm
  - Measuring
  - Triggered (Stateless/Pulse)
  - Armed (Stateless/Pulse)
- Input Trigger Sources
  - ALARM0-1
  - EXT
  - DIO0-7

    - LAN0-7
- Overload
    - The logical OR of the overload state of any combination of channels may be used as the Event Source

RETRIEVING DATA

The Digitizer driver provides three ways to retrieve data from the EX1403A. By default, the acquired data is stored in the instrument's FIFO buffer. The data in the FIFO can then be read using the standard *Read* method. An alternative option is to use data streaming. The streaming mechanism makes it possible to transfer data with less latency and overhead than the standard FIFO *Read* method; complete records will be pushed to the driver by the firmware as soon as they become available. The third method allows data to be written to a USB Storage device that is directly connected to the EX1403A. The data can then be later accessed by connecting the same USB device to any PC.

FIFO Read

Once the measurement is triggered and data becomes available in the instrument's FIFO buffer, data can be retrieved using the *Read* method in the *Measurement* interface. The *Read* method returns the specified number of data records from all enabled input channels in a channel order in the *Channels* array. The *NumFIFORecords* property in *Measurement* interface returns the number of data records currently available in the instrument's FIFO buffer. This value decreases when the data is retrieved by the host and increases when new trigger events are processed. FIFO buffer overflow may happen when the trigger events arrive faster than the host can retrieve data.

Streaming

Streaming data is an alternative method for retrieving data from the EX1403A. Unlike the FIFO read function, instruments send new data records to the host PC as soon as it becomes available when streaming data. The data is kept in the host memory buffer managed by Digitizer driver. The data in this memory buffer is then retrieved to the user's application through the *MemoryRead* method. The streamed data can be directly written into disk files or passed to a user's callback method. To use this streaming mechanism, it must be enabled by calling the *EnableStreaming* method in the *StreamingData* interface.

The key advantage of the streaming method over the FIFO Read method is data transfer speed and latency.

USB Storage

When saving data to USB Storage is enabled, any data added to the instrument's FIFO buffer is removed from it immediately and written to the USB Storage device in either HDF5 or CSV format. This allows data to be saved in permanent storage even when a driver session is not connected to the instrument. USB Storage can also be enabled at the same time as Streaming, providing a redundant data collection mechanism.

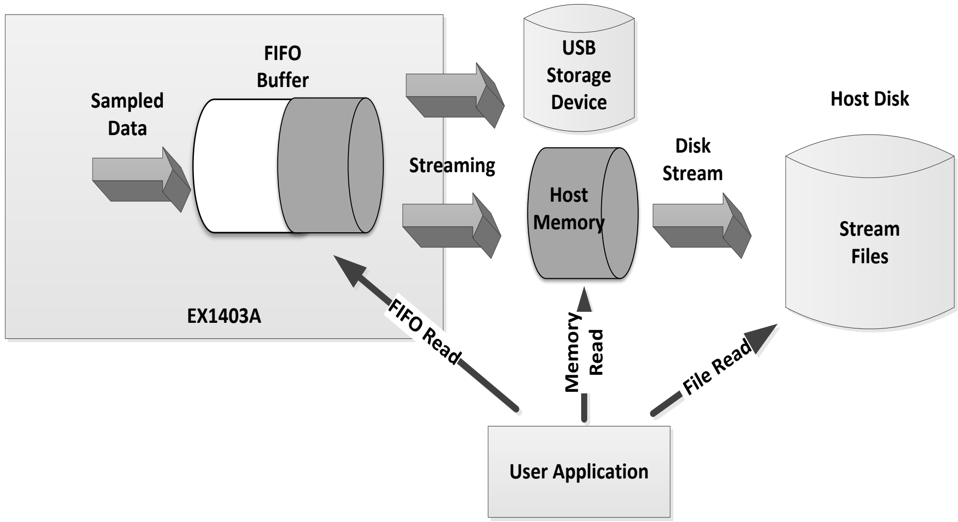


Figure 5-5: FIFO Read and Streaming

REFERENCE CLOCK AND TIME STAMPS

The *Source* property and *TimestampSource* property in the *ReferenceOscillator* interface configure the reference oscillator to generate an ADC sampling clock and data time stamp clock. The PXIe_CLK100 (100 MHz) reference signal is used by default. When the system is synchronized to the IEEE 1588 PTP grand master via Ethernet, the IEEE 1588 clock can be used as a reference oscillator be selecting “System”.

LXI AND LAN EVENTS

The EX1403A can act as an LXI device. These instruments can be synchronized to an IEEE 1588 PTP grand master clock. They can be armed or triggered by LAN events or they can generate LXI LAN events to synchronize with other LXI devices through the IVI-LXISync interface defined in the IVI driver specifications.

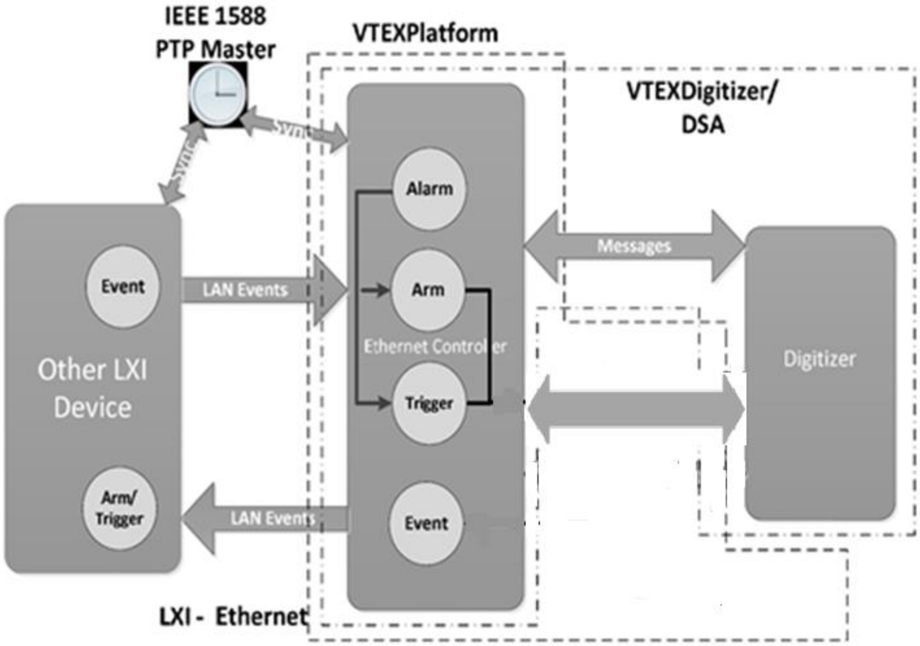


Figure 5-6: LXI and LAN Events

IVI CLASS COMPLIANT INTERFACES

In addition to the IVI-LXISync interface, the VTEXDigitizer/VTEXDsa drivers expose the IVI-Digitizer and IVI-Scope class compliant interfaces. These interfaces are exposed for the instrument's interchangeability, but their use is not recommended. These IVI interfaces do not support the full capabilities of the EX1403A's sophisticated trigger model and many other features.

MULTIPLE INSTRUMENTS

INITIALIZING WITH MULTIPLE INSTRUMENTS

Unlike many typical instrument drivers, the Digitizer drivers allow multiple EX1403A devices and other EMX devices to be controlled as if they were a single, collective instrument. The user can initialize a single driver for two EX1403A devices and treat them as a single, 32-channel instrument instead of creating two driver sessions with 16 input channels each. Multiple types of device can also be included in the driver session.

When initializing the driver session, the resource name is passed as an argument to the *Initialize* method that specifies which instruments will communicate. The resource name has the following syntax:

```
<address 1>[ ::<slot 1>,<slot 2>,..,slot N> ] | <address 2> [ ::<slot 1>,<slot 2>,…,<slot M> ] | …
```

Where:

`<address x>` is the IP address or host name of the EX1403A or EMX-2500 controller (of the PXIe chassis, where EMX series cards are installed)

`<slot x>` is the slot number identifier of the instrument in a chassis. The slot number identifier is a string such as “slot0_5” which indicates the 5th slot of the first chassis controlled by an EMX-2500. An identifier such as “slot1_6” indicates the 6th slot of the 2nd chassis extended by a bus extender. (Bus extenders are not supported by all devices.)

The slot numbers are optional. When no slot numbers are specified, all supported instruments within the chassis will be used. The slot number for all EX1403A instruments is “inst0”, but this can always be safely omitted.

When connecting to more than one EX1403A or EMX-2500 controller, the addresses must be concatenated with the “|” (pipe) character.

The resource string to connect to a particular device can be found on the Index web page (see *Index* in *Section 4*.

MULTIPLE INSTRUMENT COORDINATION

When the driver session contains multiple EX1403A and EMX devices, the *Sync* and *ReferenceOscillator* interfaces must be used to synchronize the sampling clocks and trigger models on each device to have the best sample-to-sample alignment during measurements.

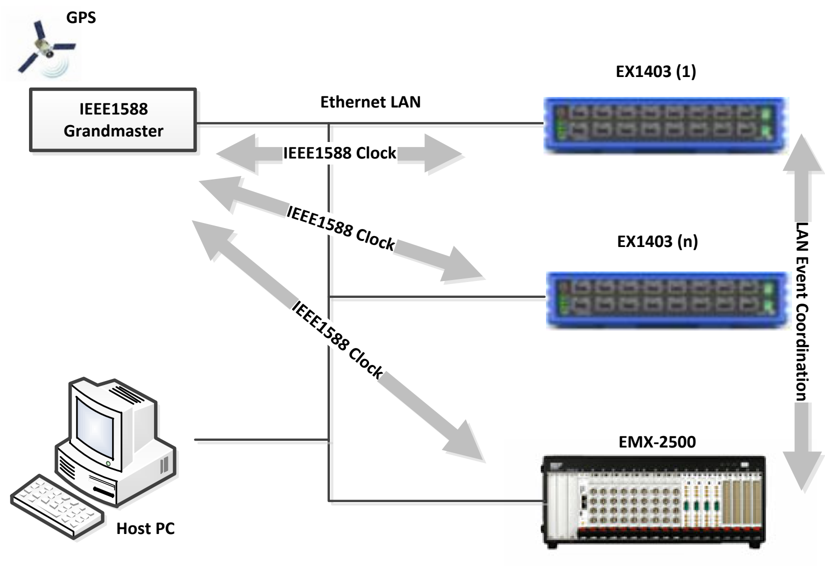


Figure 5-7: LAN Coordination

Before enabling LAN coordination, each EX1403A and EMX-2500 controller must be configured to use PTP2 as the time source (see Time Configuration in Section 4). All devices must use the same value for the PTP Domain. They must also be configured to use the same value for LXI Domain via the web page or using the Platform driver.

After opening the Digitizer/DSA driver session, the *ReferenceOscillator.Source* and *ReferenceOscillator.TimestampSource* properties must be set to “System” (IEEE 1588). The *Sync.Line* property must be set to a comma-separated list of sources for the sync signal, such as “ALARM0” or “ALARM0,PXI0”. The *Sync.CoordinationLine* property must be set to a comma-separated list of signals (beginning with “LAN”) to use for the coordination subsystem, e.g., “LAN” or “LAN,PXI0”. Note that EMX devices require specifying a hardware line in addition to LAN when setting the *Sync.CoordinationLine* property. See the Digitizer/DSA driver documentation for more information.

The most convenient way to ensure the correct settings for synchronization/coordination is to configure the desired arm sources, events, and trigger sources, then call the *Sync.AutoConfigure* method. This selects the best values for the *Sync.Line* and *Sync.CoordinationLine* properties based on the devices in the driver session. See the Digitizer/DSA driver documentation for more information.

LAN coordination may cause unexpected confusion in rare circumstances if the devices are separated by a long distance or network communication is slow. For example, when an analog channel detects a trigger, it sends a LAN message to all devices so that they trigger at the same time. If another channel from a different device also detects a trigger condition before it receives the LAN event from the device that detected the previous trigger condition, the multiple triggers cannot be processed correctly. In order to avoid this scenario, the user may need to set restrictions so that only certain channels can detect trigger events.

DATA ACQUISITION

DATA FLOW

The EX1403A instruments have a dedicated A/D converter at each analog input channel. The A/D converter samples analog data at fixed frequency specified by a multiple of the *ClockFrequency* (F_C). The output data rate of the ADC is F_C. The digitized data by the A/D converter is decimated and filtered by multiple stages of digital filters until the signal is band limited to the desired frequency span and the sample rate (F_S). These band-limited samples are constantly sent to the FIFO memory buffer located in DRAM.

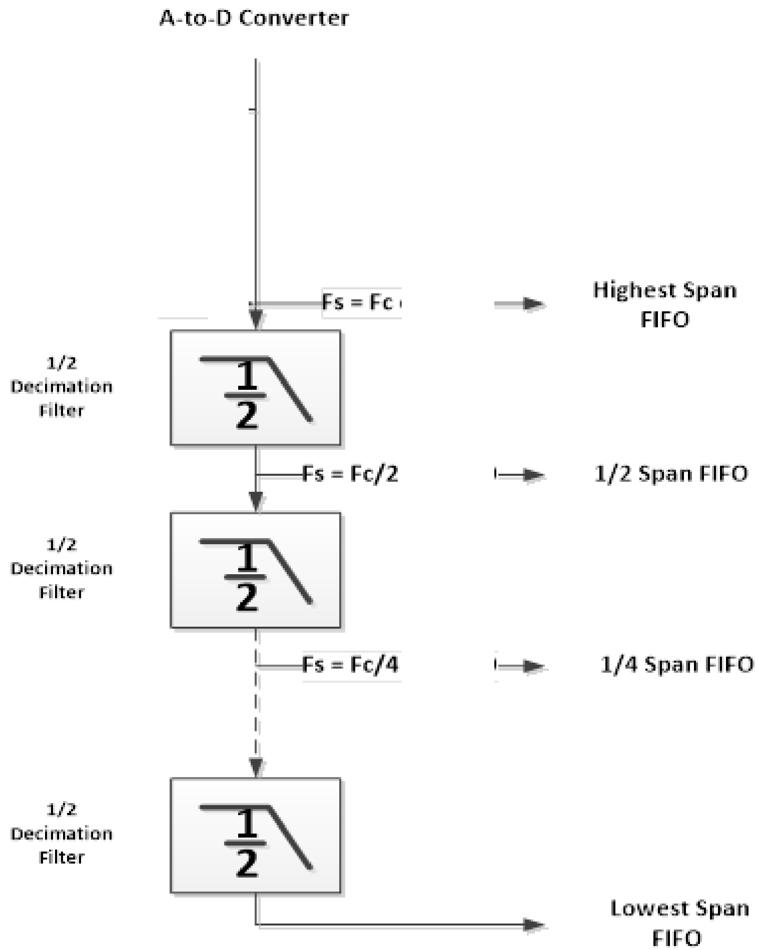


Figure 5-8: Decimation Filter and Measurement Span

FIFO

The decimated and band-limited samples by decimation filters are temporarily stored in a circular buffer (or FIFO) until the data is read out and transferred to the host.

The figure below illustrates the circular data buffer (FIFO). The figure shows three unread data records in the data buffer. The white *unused space* and *over-writable space* are the areas where new data can be written until this data buffer becomes full.

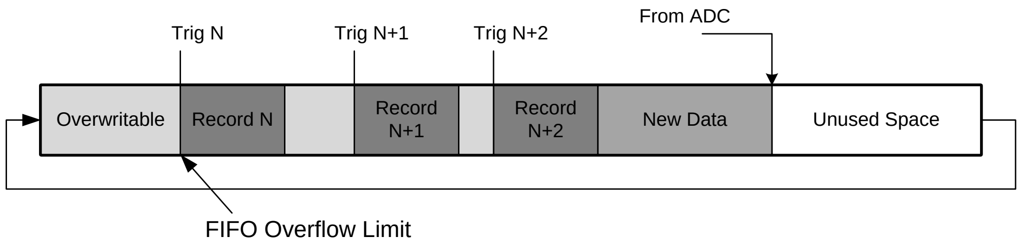


Figure 5-9: Circular FIFO

When the FIFO buffer is full and there is no more space to write new data to the FIFO, the measurement is aborted. After the last data record in the FIFO is read, a FIFO overflow error will be issued to indicate why the acquisition was stopped.

Data Streaming

The digitizer and DSA drivers come with an optimized data-reading interface for high speed and/or low-latency acquisitions. This interface relies on a separate thread which receives data asynchronously from the instrument as soon as it is available and acts on it immediately based on user-set preferences. There are several streaming modes, any of which can be enabled at the same time.

Memory Streaming

Memory streaming is the default mode for these instruments. When the user enables Streaming without any configuration, the data is streamed into a dynamically allocated buffer on the host PC and then retrieved via a Read-like interface. This is the fastest streaming interface, since memory is the fastest storage device on the PC. However, this mode is unsuited for long acquisitions because it can grow beyond the memory limits of the device and start paging to disk. The internal buffer grows as needed but does not shrink until streaming is disabled.

Additionally, this mode can be set to watch only select channels of interest. If the *MemoryChannelsList* property is set, the data for only the selected channels will be streamed to memory.

If another type of streaming is enabled while memory streaming is enabled, memory streaming is disabled unless the *MemoryChannelList* property is set.

Disk Streaming

Disk streaming is intended for high performance applications and/or long acquisitions. When enabled by setting a filename, the driver optimizes the data path by not converting the data from the native VRT data format. The data is written to disk in the HDF5 data format. For more information on HDF5 file formats and tools, visit the HDF Group's website: https://www.hdfgroup.org.

The Digitizer driver uses an HDF5 file hierarchy that is very similar to the layout used for the Data Logger feature. See HDF5 File Hierarchy in Section 6 for more details.

The disk streaming file includes several HDF attributes that describe the instrument configuration at the time that an acquisition was initiated. Additional user-defined attributes can be set by using the *SetCustomAttributes* method. The *GetCustomAttributes* method allows the user to inspect the attributes that are currently set. *RemoveCustomAttribute* and *RemoveAllCustomAttributes* can be used to remove attributes that are no longer needed.

If *Measurement.Initiate* is called multiple times without changing the *Filename* property, the existing file will be overwritten with the new acquisition data.

Disk streaming has the same limitations as the underlying filesystem. For example, a FAT32 filesystem cannot support files larger than 4GB. If disk streaming is used on a FAT32 filesystem and the file grows too large, errors and data loss may occur. In addition, disk streaming throughput may suffer when the underlying filesystem is very slow, such as a USB 2.0 external drive.

Callback Streaming

Callback streaming is enabled when the user registers one or more callback functions, which are called with available data when it is ready. The user's code may then act on the data. To register a callback, the user will have to override the COM abstract interface (when using the IVI driver) or C++ pure-virtual callback class (when using the Linux driver), and then pass this class to the *RegisterStreamingCallback* method. The data is returned in the same format as the *MemoryRead* method, as can be determined from examining these classes.

Support for registering a callback to receive data only from certain channels, similar to using the *MemoryChannelList*, is scheduled for a future driver release.

Storage Devices

The Storage Devices interface provides an alternative to streaming data back to the driver session. It allows data to be written to USB Storage Devices connected directly to the EX1403A, without any data being transmitted via Ethernet. This interface supports all the same configuration options as Disk Streaming, plus the ability to choose between HDF5 and CSV file format. Data will continue to be written to the USB Storage Device, even if the connection between the EX1403A and driver session is interrupted. USB Storage Devices can be used in conjunction with any of the other streaming data methods; in this case the same data will be sent to both the USB Storage Device and the driver's streaming interfaces.

SAMPLING RATES

The properties in the *Sampling* interface configure the A/D converter and decimation filters to specify the sampling rate and frequency span of the data to be acquired. Some properties in this interface are interrelated. Changing one property value can affect the other.

There is a *Sampling* property in the *Measurement* interface as well as the individual *Channel* interface. The properties in the global *Sampling* interface that apply to all channels as well as DIO can be configured from the *Measurement* interface, while the *Channel* interface allows the user to configure each channel independently.

ClockFrequency

The *ClockFrequency* specifies the A/D conversion rate. This property determines the highest *SampleRate* of the data acquisition session. The highest rate can be achieved by bypassing all decimation filters. There are discrete sets of *ClockFrequency* values that the user can specify depending on the instrument model. See instrument specification for the list of *ClockFrequency* values. *ClockFrequency* is a global parameter. It cannot have different values for each channel. While it is possible to have different *ClockFrequency* values between instruments in a single driver session, it would be more convenient to have multiple driver instances for each *ClockFrequency*.

Prescaler

This is the sampling rate divider before the ADC data is decimated by the ½ decimation filter stages. The EX1403A only supports a value of 1 for *Prescaler*, which has no effect on measurement data.

DownsamplingFactor

This is the amount of unfiltered downsampling that will be performed after the decimation filtering by the selected *FilterType*. The EX1403A supports all integers from 1 to 65536.

FilterType

This specifies the type of digital filter that will be used to decimate and filter the data. Four options are available: *High Performance*, *Medium Latency*, *Low Latency*, and *None*. *None* disables all digital filtering, such that effective *SampleRate* is equal to *ClockFrequency* divided by *DownsamplingFactor*.

FilterType=None configures the instrument the same way as setting *SampleRate*=*ClockFrequency* with any other *FilterType* -- that is, all digital filtering is disabled, and the undecimated data from the ADC is passed straight to the user (after calibration and EU conversion of course). This means the group delay of digital filter is 0. *HighPerformance* is an FIR filter with 0-16 divide-by-2 stages. This provides optimal performance but has high group delay. The decimation ratio can only be powers of two up to 2^{16}. This filter's response can be customized by providing normalized filter coefficients. *LowLatency* is a CIC filter capable of any integer decimation ratio from 4 to 8192. This provides the lowest group delay but is only suitable for use with DC inputs. *MedLatency* pairs the CIC filter with a Compensating FIR (with decimation ratio of 4) at its output. This increases the group delay, slightly, while providing a better response across a variety of input frequencies. Valid decimation ratios are all multiples of 4 from 16 to 65536. The *MedLatency* filter's CFIR can also be customized by supplying normalized filter coefficients.

SampleRate

This is the effective data rate. The inverse of *SampleRate* specifies the interval between data samples that the user can obtain. The *ClockFrequency*, *DownsamplingFactor*, and *SampleRate* determines the amount of decimation and filtering performed by the filter indicated by *FilterType*. Some instruments support setting different *SampleRate* values on channels in a single instrument. For EX1403A, the *SampleRate* is a global property and will always be the same for all channels in the same instrument. The decimation ratio of the selected filter will be set to *ClockFrequency* / *DownsamplingFactor* / *SampleRate*, rounded down to the next valid value for the chosen *FilterType*.

Span

The *Span* is the nominal frequency range of the acquired signal. The value of *Span* is determined by the decimation filter's cutoff frequency. The ratio between *Span* and *SampleRate* varies based on the selected *FilterType*. See the instrument specifications table for the precise value for each filter.

FilterCoefficients

The normalized filter coefficients of the *HighPerformance* and *MedLatency* filters can be programmed by the user to achieve optimal results for their particular application. These are each 32-tap FIR filters with 64 coefficients.

GroupDelay

The *GroupDelay* parameter specifies the delay of each stage of the FIR and CFIR filters used by the *HighPerformance* and *MedLatency* filters, respectively, in units of undecimated samples. By default, this value will be correct for the preprogrammed value of *FilterCoefficients*. If, however, a custom set of coefficients is supplied, this property should be set with the correct group delay for those coefficients. This allows the firmware to perform group delay compensation on measured data correctly with the customized filter response.

RecordSize

The *RecordSize* specifies the number of data samples read back from the instrument at a time. The total number of data samples captured for each trigger is equal to the product of *RecordSize* and the *Measurement.NumRecordsPerTrigger* property -- that is, *NumRecordsPerTrigger* records are captured, and each is of size *RecordSize*. The figure below shows the case where *NumRecordsPerTrigger* = 4. As a special case, when *NumRecordsPerTrigger* is set to 0, an infinite number of data records are returned in *RecordSize* sample chunks after a trigger event until the measurement is aborted.

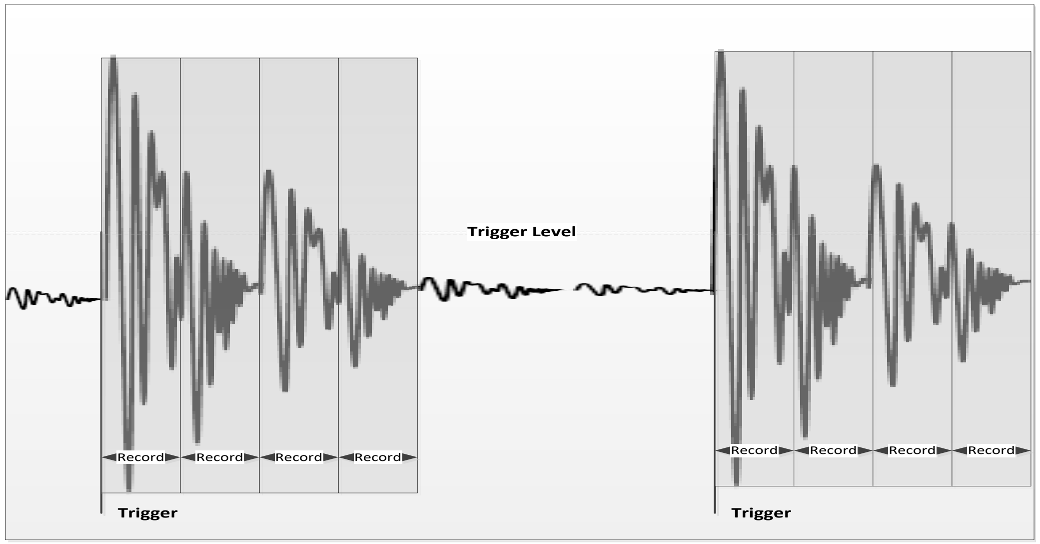


Figure 5-10: Record Size and *NumRecordsPerTrigger*

With EX1403A, the minimum *RecordSize* is 1 and the maximum power of 2 *RecordSize* is 32768. Since each data packet transferred from the instrument to the host contains one data record from each ADC channel, in general, the user can achieve higher data transfer using a larger *RecordSize* value due to reduced overhead, but this affects the data update interval, as the amount of time to acquire one data record is: T = *RecordSize*/*SampleRate*.

Oversample

When the *Oversample* is set to true, the data is twice oversampled than Nyquist sample rate. The *SampleRate* becomes 5.12 times of *Span*. The *Oversample* mode is currently not supported.

Multipass

When the *Multipass* property is set to true, the data record contains data samples from multiple ½ decimation spans below the current decimation span specified by *Span* property. The *RecordSize*/2 samples is at *Span*, *RecordSize*/4 samples is at *Span*/2, *RecordSize*/8 samples is *Span*/4, etc., until it reaches less than 1 sample or the lowest decimation stage. *Multipass* is currently not supported.

DIO Sample Rate

The EX1403A's DIO port can record its input state at the same rate as the analog input channels. Because this data is purely digital and binary, it cannot be decimated. All DIO data is downsampled with no filtering such that the DIO sample rate is always equal to the analog channels' final sample rate. For that reason, only *ClockFrequency* and *SampleRate* are available in the *DIO.Sampling* interface – *FilterType* is not supported. Attempting to set either the channel or DIO sample rate will always cause the other to be set to the same value.

OVERLOAD DETECTION

When the analog signal amplitude exceeds the input range, the digitized samples are truncated resulting in a distorted waveform. To avoid this, users can increase the input range of the instrument, attenuate the signal level, or discard overloaded data from processing. Apart from over-range, there are other fault conditions that can invalidate measurement data, such as open transducer. The EX1403A can detect some of these common fault conditions and reporting it, allowing the user to act.

The fault status can be queried from the Digitizer and DSA driver's API. The status can be indicated at the front panel LED's on RJ45 connector. The information is also associated to the acquired data record and returned in *AdditionalData* string.

The Digitizer and DSA drivers define each fault status as an *Overload Status* bit field. The user can configure which fault conditions to reported, if an LED indicator is shown, or it can latch so that the momentarily fault won't be overlooked.

Bit Field	Description	EX1403A
0x00000008	Exceed upper user limit	Yes
0x00000010	Exceed lower user limit	Yes

Table 5-2: General Fault Status Bit Support

Bit Field	Description	EX1403A
0x00010000	ADC overload (This includes differential and common mode overload)	Yes
0x00080000	Analog Power Fault	Yes

Table 5-3: Instrument-Specific Fault Status Bit Support

TIME STAMP

During data acquisition, the EX1403A returns timestamps along with digitized analog data. The timestamps are created based on the *TimestampSource* clock specified in *ReferenceOscillator* interface. When IEEE 1588 synchronized time stamps are desired, the *TimestampSource* property must be set to *ReferenceOscillatorTimestampSourceSystem*. Otherwise, the time returned will be the time elapsed since the SYNC signal was received.

When measurement data is retrieved, both a timestamp of the data record and a timestamp of trigger event are returned. The combination of *TimeSeconds* and *TimeFraction* parameters indicate the time of the first data sample in each retrieved data record. The time of trigger event is returned in the *AdditionalData* parameter.

Timestamp Source	Timestamp value	Resolution
System (IEEE 1588)	PTP or TAI (International Atomic Time)	40 ns
PXIe_CLK100	Elapsed time from last SYNC	40 ns

Table 5-4: Timestamp Source and Resolution

ADDITIONAL DATA

The additional information associated with the data records are returned as a JSON (Java Script Object Notation) array of name/value pairs:

[[JSON array for channel 1's first record], [JSON array for channel 2's first record], ….]

The JSON object array for each channel is:

[{Object1}, {Object2}, …]

Each object is a list of name/value pairs:

{name1:value1, name2: value2,…}

Table 5-5: Additional Data JSON Names and Values

Object	Name String	Value
Over range	timestamp_sec	Over-range start time in seconds
	timestamp_frac	The fraction portion of over-range start time
	Over-Range Count	# of over ranged samples from the start time.
Trigger time	Trigger Timestamp Seconds	The trigger timestamp in seconds
	Trigger Timestamp Fraction	The fraction portion of trigger timestamp.
Dropped trigger	timestamp_sec	The timestamp of when the trigger would have occurred.
	timestamp_frac	The fraction portion.
	Trigger Dropped	The channel name of the lost trigger.
Fifo Overflow	timestamp_sec	The timestamp of when the fifo overflow occurred.
	timestamp_frac	The fraction portion.
	Fifo Overflow	The channel name of the fifo overflow.

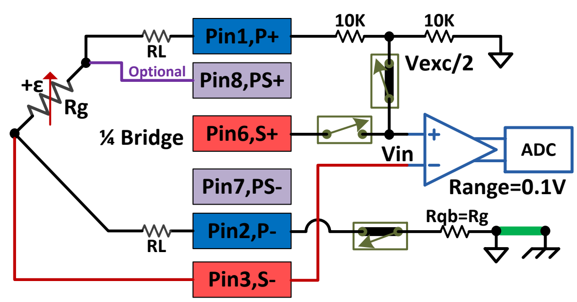
ENGINEERING UNIT (EU) CONVERSION

Each EX1403A input channel can be individually configured for strain or resistance measurement by specifying input channel *Function* to Strain or Resistance. Setting a specific conversion not only controls the mathematical operations applied to the acquisition data, but also automatically configures elements of the signal conditioning path In these measurement functions, the properties under Strain interface are used to configure the instrument. Returned data are converted to engineering units.

Strain Measurement

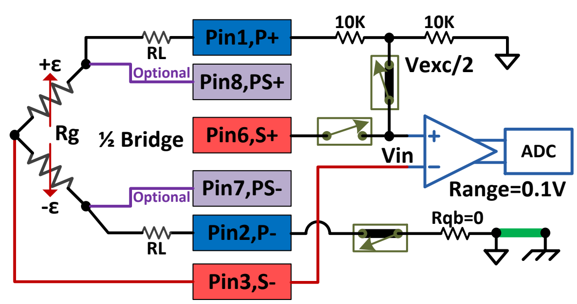
$V_{diff} = V_{in} - V_{unstrained}$; $V_{unstrained}$: V_{in} when strain (ε) = 0
V_{in}: Voltage measured across Bridge the by the front-end Instrumentation Amplifier
R_L: Lead Wire resistance used to compute lead wire desensitization factor $\left[1+\frac{R_L}{R_G}\right]$
GF: Gauge Factor = $\left(\frac{1}{\varepsilon}\right)\left(\frac{\Delta R}{R_G}\right)$; R_G: Gauge Resistance
V_{Exc}: Excitation Voltage ; I_{Exc}: Excitation Current
V_R: Voltage measured across the Resistor by the front-end Instrumentation Amplifier

<table>
<tr><th>Strain Engineering Units (EU) Equations</th><th>Connection</th></tr>
<tr><td>Quarter Bridge

$$\varepsilon = \left[\frac{4V_{in}}{(GF)(V_{Exc}-2V_{in})}\right]\left[1+\frac{R_L}{R_G}\right]$$</td><td>
</td></tr>
<tr><td>Half Bridge Bending

$$\varepsilon = \left[\frac{2V_{in}}{(GF)(V_{Exc})}\right]\left[1+\frac{R_L}{R_G}\right]$$

Half Bridge Poisson

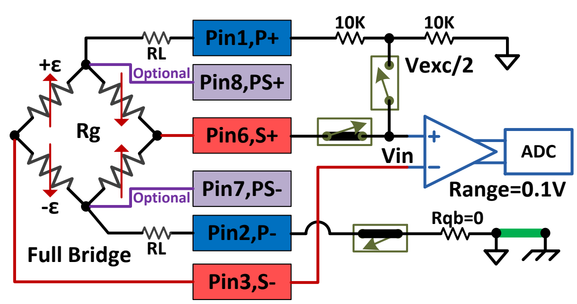
$$\varepsilon = \left[\frac{4V_{in}}{(GF)[V_{Exc}(\nu+1)+2V_{in}(\nu-1)]}\right]\left[1+\frac{R_L}{R_G}\right]$$</td><td>
</td></tr>
<tr><td>Full Bridge Bending

$$\varepsilon = \left[\frac{V_{in}}{(GF)(V_{Exc})}\right]\left[1+\frac{R_L}{R_G}\right]$$

Full Bridge Poisson

$$\varepsilon = \left[\frac{2V_{in}}{(GF)[V_{Exc}(\nu+1)+V_{in}(\nu-1)]}\right]\left[1+\frac{R_L}{R_G}\right]$$

Full Bridge Bending Poisson

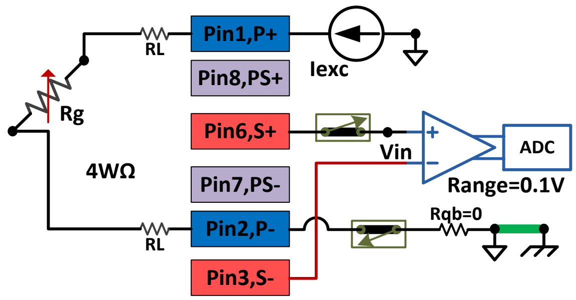
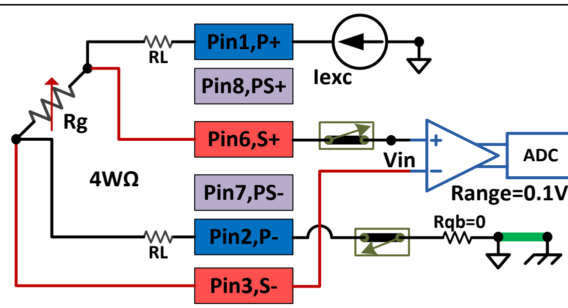
$$\varepsilon = \left[\frac{2V_{in}}{(GF)[V_{Exc}(\nu+1)]}\right]\left[1+\frac{R_L}{R_G}\right]$$</td><td>
</td></tr>
</table>

Resistance Measurement

By specifying input channel *Function* to Resistance, and *BridgeType* to one of predefined types, the instrument automatically configures internal circuit and returned data is converted to Ohms.

Common terms used in the conversion equations are the following:

> *Ω* = resistance $V_{Exc=}$ Excitation Voltage ; $I_{Exc=}$ Excitation Current; R_G: Gauge Resistance
> V_{in}: Voltage measured across the Resistor by the front-end Instrumentation Amplifier

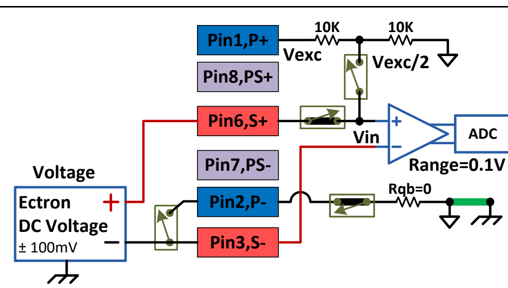
Ohms Engineering Units (EU) Equations	Connection
2-Wire Ohm DC $$\Omega = \left[\frac{V_{in}}{I_{Exc}}\right] = R_G + 2R_L$$	
4-Wire Ohm DC $$\Omega = \left[\frac{V_{in}}{I_{Exc}}\right] = R_G$$	

Voltage

This simply returns the differential voltage, Vdiff.

Vdiff =V+sense –V-sense

Setting this conversion automatically configures the input path for full-bridge mode, in which the completion resistor is shorted, and the back-half resistors are disconnected. This configuration is illustrated in below table

Ohms Engineering Units (EU) Equations	Connection
Voltage: connect P- to S- if the Voltage Source and EX1403are not connected to chassis/earth ground	

Ratiometric

This performs a scaling of the differential voltage, Vdiff, according to:

$$V_{\text{diff}} = V_{\text{+sense}} - V_{\text{-sense}}$$
$$V_r = \frac{V_{\text{diff}} - V_{\text{unstrained}}}{V_{\text{excitation}}}$$

Setting this conversion automatically configures the input path for full-bridge mode, in which the completion resistor is shorted, and the back-half resistors are disconnected.

Linear Conversion

EX1403A can perform linear EU conversion by specifying a polynomial coefficients using *Channel.Transducer.SetConversion()* method. Only the first order polynomial (mx+b) is supported. This conversion applies in addition to the standard EU conversion performed by the *Channel.Function*.

GAGE FACTOR / POISSON RATIO

As illustrated in the Engineering Unit (EU) Conversion subsection, there are two constants utilized in the EU strain conversions: gage factor and Poisson ratio. The gage factor (GF), a measure of strain gage sensitivity, is a dimensionless quantity defined as the ratio of the fractional change in resistance to the fractional change in length along the primary axis of the strain gage. Mathematically, this is expressed as:

$$\text{GF} = \frac{\Delta R / R}{\Delta L / L} = \frac{\Delta R / R}{\varepsilon}$$

The gage factor value for a specific strain gage is provided by the strain gage manufacturer. The default gage factor is 2.0. The Poisson ratio (ν), in simple terms, is a measure of the extent to which a material contracts as it is being stretched. In engineering terms, it is a dimensionless quantity defined as the ratio of transverse contraction strain to longitudinal extension strain in the direction of the stretching force. Mathematically, this is expressed as:

$$\nu = \frac{-\varepsilon_{\text{trans}}}{\varepsilon_{\text{long}}}$$

The Poisson ratio value for a specific material should be obtained from a mechanical engineering reference. The default Poisson ratio is 0.3.

EXCITATION SOURCE

Each EX1403A input channel features an independent programmable excitation source. This excitation source can be programmed to 0.5V,1V,5V and 10V. with a total current capability of 30 mA per channel with overcurrent protection. The operations to program and enable each excitation voltage are discrete. Excitation voltages that are not enabled output an actual value of 0 V, regardless of their programmed value.
When the excitation source is changed, the nominal value of the total excitation voltage is updated in the EU strain conversions. However, for highest accuracy, the excitation voltage should be measured, and the measurement used in the EU conversion
For highest accuracy in half-bridge and full-bridge configurations, each excitation source has a remote sense connection. In order to properly remove the effects of lead wire resistance, these lines should be connected at the same point that the ±Excitation lines are connected to the bridge. The remote sense lines are always active in the

circuitry; there is no control to turn on/off remote sense. Because of this, it is critical that they be left open (unconnected) in quarter-bridge configuration, where their connection would be invalid

To maximizing measurement performance, because of the relatively high levels of power dissipation involved, it is best to allow the bridge system elements to thermally stabilize after an excitation source change. Excitation and unstrained voltage measurements taken after an appropriate wait time (~30 minutes) will demonstrate improved stability during the subsequent strain testing.

MEASUREMENT PROCESS

MEASUREMENT SETUP

When the driver session is initialized by the *Initialize* method, the driver session is reset, or after the previous measurement is finished, the instrument is in the *Idle* state. While in the *Idle* state, the user prepares for the next data acquisition by configuring the setup parameters. For more information, please refer to IVILXISync standard API documentation.

Sync and Coordination

The *Sync* interface controls how the EX1403A synchronizes its ADCs and its timestamp counter. When a sync event occurs, all ADCs in the system are synchronized to each-other, and all data timestamp counters are reset and, if using the System Timestamp Source, synchronized to the IEEE 1588 clock. If the *Sync.CoordinationLine* property is set to “LAN”, all instruments in the driver session will use LXI Lan Event messages to coordinate their trigger state machines, ensuring that all arm and trigger events are shared between all instruments in the system.

Start, Arm, and Trigger

Properties in the *Start*, *Arm*, and *Trigger* interfaces configure the data acquisition gating condition and timing. *Start* determines when the data acquisition starts and when the instrument is ready for the next acquisition. All hardware configuration and filters settling should be completed before the *Start* event in order to ensure valid data is acquired.

Sampling Parameters

The sampling parameters are specified by properties in *Sampling* interface. *Sampling* in the *Measurement* interface configures parameters common to the entire system. Optionally, the user can configure the parameters of individual input channels using the *Channels* interface (with some restrictions).

Analog Front End

While some parameters can be changed during data acquisition, most configuration options should be performed prior to data acquisition to avoid data glitches. Most front-end parameters can be configured independently for each input channel. The front-end configuration includes input range, voltage/strain/resistance input function, and function-specific properties.

MEASUREMENT INITIATION

After the user has completed configuring the instrument, the user can initiate the data acquisition process by calling the *Initiate* method in the *Measurement* interface. During measurement initiation, the instrument starts to prepare for the actual data acquisition. If the ADC has not been synchronized, the SYNC signal is sent and ADC then begins digitization. When the ADC’s reference oscillator has been changed, the ADC sampling clock must be re-locked with the PLL. Filter settling also occurs at this time. Once the filters have settled and the instrument is ready to acquire valid data, the measurement moves to the *Wait for Start* state. The source of the *Start* event is *Immediate* by default. In this case, the measurement starts automatically. Otherwise, it must be started by an event specified by the *Source* property of the *Start* interface.

During this period, the digitized signal from the A/D converter is continuously filtered and discarded until the filters have settled. Once settled, the filtered data samples are stored in the internal data buffer.

MEASUREMENT LOOP

Once the measurement begins, the state machine cycles through arming and triggering for the number of times specified by *ArmCount* and *TriggerCount.* The measurement stops when the specified number of arm and trigger loops are completed, when it is aborted by an *Abort* command, or when the FIFO buffer becomes full and the FIFO mode is set to *Stop*.

ARMING

Arm is the gating condition to acquire data. In order to trigger data acquisition, the measurement must be armed first. There are several ways to arm a measurement. The default condition is to arm automatically (or *Immediate* arming).

Self-arming

When the *Immediate* arm source is enabled, the EX1403A arms by itself.

Arming by User's Command

The EX1403A arms by the *SendSoftwareArm* method when a *Software* arm source is enabled.

Arming at a Certain Time Interval

The EX1403A can be armed at a specific time interval using the ALARM0-1 arm sources. In addition to enabling the alarm as an arm source, it must be configured and enabled using the *Alarm* interface.

Arming by External Pulse

The EX1403A can receive an arm from the back-panel trigger SMB connector by enabling the EXT arm source.

Arming from DIO Lines

The EX1403A can receive an arm event from the digital I/O port by enabling the DIO arm sources.

Arming from LAN Events by Other Instruments

The user, or another LXI device, can send LAN events to arm the EX1403A using the Digitizer driver. Alternatively, a LAN event can be sent to the EX1403A using the Platform driver.

TRIGGERING

When the measurement is armed and when there are enough digitized samples already collected in the FIFO for pre-trigger delay, the measurement becomes ready to receive a trigger event.

Self-triggering

When the *Immediate* trigger source is enabled, the EX1403A triggers automatically and acquires data records as soon as it is ready to receive a new trigger event.

Triggering by User's Command

The EX1403A triggers by the *SendSoftwareTrigger* method when a software trigger source is enabled.

Triggering at a Certain Time Interval

The EX1403A can be triggered at a specific time interval using the ALARM0-1 trigger sources. In addition to enabling the alarm as a trigger source, it must be configured and enabled using the *Alarm* interface.

Triggering by Analog Signal

The EX1403A is triggered when an analog signal at an input channel crosses the trigger threshold level. To trigger from the analog signal, the channel must be enabled as a trigger.

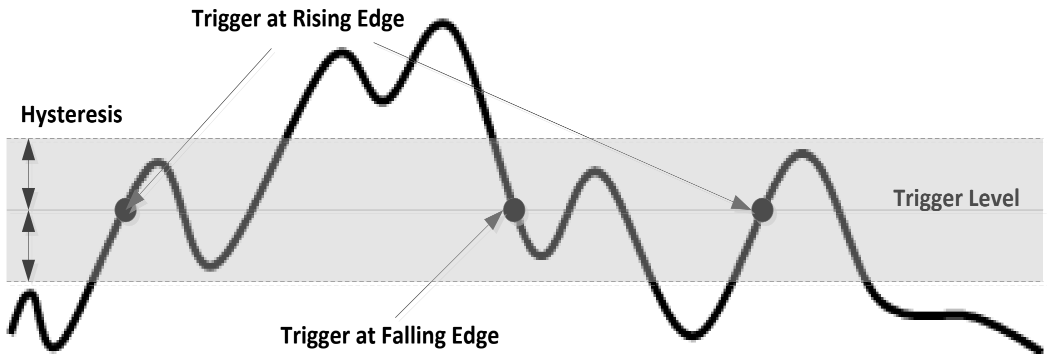


Figure 5-11: Triggering by Analog Signal

Triggering by External Pulse

The EX1403A can receive a trigger from the back-panel trigger SMB connector by enabling the EXT trigger source.

Triggering from DIO Lines

The EX1403A can receive a trigger event from the digital I/O port by enabling the DIO trigger sources.

Triggering from LAN Events by Other Instruments

The user, or other LXI device, can send a LAN event to trigger the EX1403A using the Digitizer driver. Alternatively, a LAN event can be sent to the EX1403A using the Platform driver.

DATA RETRIEVAL

After a measurement is triggered and at least one record of data (the number of samples specified by *RecordSize* property in *Sampling*) is available in FIFO buffer, it can be retrieved using the *Read* method in *Measurement* interface or via the *Streaming* method described in the Data Acquisition section in this manual. At each trigger event, the number of contiguous records specified by *NumRecordsPerTrigger* are acquired. Multiple records can be read separately or all in once if they are available in the instrument's FIFO buffer. The *Read* method in *Measurement* returns at least one record from all enabled channels.

When the user wishes to acquire continuous samples indefinitely after a single trigger event, set the *NumRecordsPerTrigger* property to 0 (infinite) and set FIFO mode to *Stop*. The data acquisition stops when the user aborted using the *Abort* method or when the FIFO buffer becomes full (FIFO overflow). In this setup, the user must retrieve data faster than the ADC data filling into FIFO to avoid FIFO buffer from overflowing.

Pipeline Delay and Latency

For high speed data recording, data transfer speed is key. For applications that require real-time data monitoring or processing, on the other hand, the data update rate becomes more important. A real-time closed loop control is an example. It is necessary to understand that there are delays at almost every stage of the data acquisition process.

Some are within the instrument while others occur outside of the instrument, such as at the transducer or in the user's application.

The analog signal conditioning circuit introduces some delay before the signal reaches the A/D converter. Usually the delay in the analog section is small and negligible.

In the digital section, the digital filters in the A/D converter and decimation filters introduce a group delay. With the *LowLatency* filter, it is 24.75 ms at 100 Sa/s and increases at lower frequency spans. The filtered data is transferred to the FIFO buffer at a specified interval (enough sample periods to cover at least 3.2 ms). Once a trigger is detected, the data in the FIFO can be read out to the user's application in blocks of *RecordSize* samples.

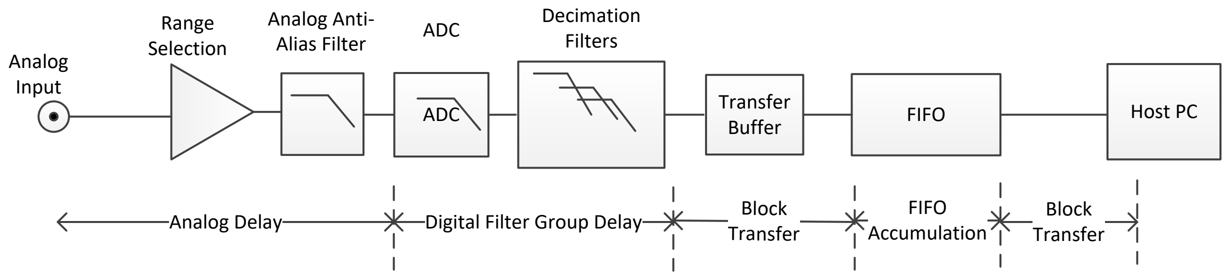


Figure 5-12: Delays in Data Path

EVENTS

Events are an optional feature allowing the EX1403A to send notifications to the user, or other instruments, when a specified event occurs. The notification can be via LAN message, EXT trigger line, or DIO output. The user can specify an event when the measurement state is armed, triggered, finished, or when an overload condition is detected on one or more channels. See the Digitizer driver's online help for more information.

WHERE TO FIND MORE INFORMATION

DRIVER API REFERENCE

The complete driver's API reference is available as online help. Each driver comes with a .chm format help file in both Windows and Linux. Newer driver revisions also integrate the driver help content into the Microsoft Help Viewer, which is used by Visual Studio 2010 and later.

Each driver comes with several useful example programs in C++ and C#.

SPECIFICATION INFORMATION

The EX1403A conforms to many industry standards in both hardware and software architecture. Although products can be used without knowing these standards, some knowledge can be useful to take full advantage of VTI Instruments products.

- LXI specification is available from LXI consortium at www.lxistandard.org
- IVI driver specification is available from IVI Foundation at www.ivifoundation.org
- IEEE 1588 Precision Synchronization Protocol Standard at www.nist.gov/el/isd/ieee
- ANSI/VITA 49.0 (VRT) is specified as a part of VITA specification at www.vita.com

SECTION 6

OPERATION OF DATA LOGGER

INTRODUCTION

The EX1403A can be used as a data logger, in conjunction with an external USB disk. There are two major use cases to this feature. First, it can be used for standalone operation, where the instrument has no connectivity to host computer. Secondly, it can be used as non-volatile storage space, where the measured data will be stored during network/host computer fault.

USB DISK SELECTION AND PREPARATION

The standard USB host port available on EX1403A supports USB 1.1 and USB 2.0 standard disks, which are formatted with EXT2, EXT3, EXT4, VFAT/FAT32, and MSDOSFS file journaling formats.

NOTE	**Typical USB thumb/pen drives may be formatted using NTFS file system, which is widely supported on latest Windows OS. However, this file system is not yet supported by EX1403A instrument, so data transfer will not take place. Before using a particular USB disk for critical applications, users are advised to test the configuration by performing a dummy acquisition.**

The maximum current available on the USB port is limited to 0.5A @ 5V. USB disks which requires more than 2.5W of power for their operation (such as USB hard disk drives) must be externally powered.

The data will be stored in either Comma Separated Values format (CSV) or Hierarchical Data Format, HDF5 file format. HDF5 is an open-source data file format with a wide variety of tools available to decompress, view and export the time stamped measurement data. For more information on HDF5 file formats and tools, visit the HDF Group's website: https://www.hdfgroup.org. The measurement data can be stored across any number of files, optionally overwriting the oldest file when the maximum is reached.

USB DISK INSERTION AND SAFE REMOVAL

It is recommended to use an empty USB disk which is containing no other data files, other than device configuration file. Whenever a USB memory device that can support data logging is inserted into the USB port of EX1403A instrument, it will be detected by EX1403A instrument, which will add a menu page to the LCD menu containing "Data Logger: sda1", "Hold MENU to run" (assuming the device is mounted at sda1). Pressing and holding MENU button for 5 seconds on this page will then begin data logging. Pressing and holding MENU button again for 5 seconds, on this page, before completion, will abort data logging.

Note	**If the USB disk is disconnected or the instrument is powered off abruptly while data logging operations are in progress, the data files may be corrupted.**

In order to safely remove a USB disk, first abort any measurement that is saving data to the disk, then navigate to the "USB at sda1" (assuming the device is mounted at sda1) page of the LCD menu and hold the MENU button for 5 seconds. Upon releasing the MENU button, the screen should change to read "Safe to remove" in place of the volume label on the second row. If an error is displayed instead, the disk is still in use by an active measurement.

CONFIGURATION OF USB DISK

To configure the data logger session, the user must place a device configuration file (config.json) in the top-level directory of the attached USB Memory Disk. It will be the same format used internally by the *Configuration.StoreCurrent* API. The user can construct this file manually or use the *Configuration.SaveConfigurationToStorageDevice* method to save the current instrument configuration to the attached USB Memory Disk. This and the other storage device configuration methods all take the repeated capability name of a *StorageDevice* item as an argument, and act on the file *config.json* within that device. The *StorageDevice* item must have the *Enabled* property set to true before the configuration is saved to that storage device.

SAVING DATA TO USB DISK

A new repeated capability, *Storage.Devices*, has been added to the VTEXDigitizer/VTEXDsa drivers to represent the attached storage devices. The data will be saved to any enabled storage devices in the selected file format (HDF5 or CSV). This API allows multiple storage devices to be enabled at the same time, or for VRT streaming to be enabled alongside them. In that case, identical data will be sent to all enabled devices and streaming sockets. FIFO polling via *Measurement.Read*, however, is only supported when all streaming protocols and storage devices are disabled, as the data is removed from the FIFO when it is sent to the storage devices and streaming sockets.

HDF5 FILE HIERARCHY

HDF5 is a hierarchical file format based on string group names, which contain datasets, which are arrays of like key-value pair collections. The root group of the HDF5 file will be "inst0", which is the same as the slot name of the instrument. This will contain one group per channel, named the same as that channel, "CH1" to "CH16", as well as "DIO". Each channel group will contain one dataset for each VRT packet type. HDF5's Packet Table type will be used to pack the raw VRT data into these datasets. Attributes will be set on the "inst0" and channel groups to indicate the instrument's configuration state at the time that the measurement was initiated.

- inst0 (group)
  - <channel> (group)
    - IF_MEAS_INFO (dataset)
      - Packet info - The upper 16 bits of the VRT Header word
      - Packet size - The total number of 32-bit words in the packet
      - Stream ID - The VRT Stream identifier
      - OUI - VTI's IEEE Organizationally Unique Identifier
      - Information class code - The VRT information class identifier
      - Packet class code - The VRT packet class identifier
      - Time seconds - The seconds portion of the packet timestamp
      - Time picoseconds upper - The upper 32 bits of the picoseconds portion of the packet timestamp
      - Time picoseconds lower - The lower 32 bits of the picoseconds portion of the packet timestamp
      - Context Indicator Field - A mask indicating which items are included in Context Fields
      - Context Fields - A list of 32-bit words comprising the data payload of the context packet
    - EX_MEAS_INFO (dataset)
      - Packet info - The upper 16 bits of the VRT Header word
      - Packet size - The total number of 32-bit words in the packet
      - Stream ID - The VRT Stream identifier
      - OUI - VTI's IEEE Organizationally Unique Identifier
      - Information class code - The VRT information class identifier
      - Packet class code - The VRT packet class identifier
      - Time seconds - The seconds portion of the packet timestamp
      - Time picoseconds upper - The upper 32 bits of the picoseconds portion of the packet timestamp
      - Time picoseconds lower - The lower 32 bits of the picoseconds portion of the packet timestamp

    - Context Indicator Field - A mask indicating which items are included in Context Fields
    - Context Fields - A list of 32-bit words comprising the data payload of the context packet
  - EX_MEAS_FLOAT32 (dataset)
    - Packet info - The upper 16 bits of the VRT Header word
    - Packet size - The total number of 32-bit words in the packet
    - Stream ID - The VRT Stream identifier
    - OUI - VTI's IEEE Organizationally Unique Identifier
    - Information class code - The VRT information class identifier
    - Packet class code - The VRT packet class identifier
    - Time seconds - The seconds portion of the packet timestamp
    - Time picoseconds upper - The upper 32 bits of the picoseconds portion of the packet timestamp
    - Time picoseconds lower - The lower 32 bits of the picoseconds portion of the packet timestamp
    - Samples - A list of 32-bit floating point data samples
    - Trailer - The 32-bit VRT trailer word
  - EX_MEAS_INT32 (dataset)
    - Packet info - The upper 16 bits of the VRT Header word
    - Packet size - The total number of 32-bit words in the packet
    - Stream ID - The VRT Stream identifier
    - OUI - VTI's IEEE Organizationally Unique Identifier
    - Information class code - The VRT information class identifier
    - Packet class code - The VRT packet class identifier
    - Time seconds - The seconds portion of the packet timestamp
    - Time picoseconds upper - The upper 32 bits of the picoseconds portion of the packet timestamp
    - Time picoseconds lower - The lower 32 bits of the picoseconds portion of the packet timestamp
    - Samples - A list of 32-bit integer data samples
    - Trailer - The 32-bit VRT trailer word

CSV FILE FORMAT

CSV is a text-based spreadsheet format, where each row is separated by a newline character (ACSII code 0x0A), and columns are separated by a comma (,) character. The following columns can be included, depending on instrument configuration:

- Time – The timestamp corresponding to any included channel data columns for this row
- CH1 to CH16 – The measured data samples for each analog input channel
- DIO Time – The timestamp corresponding to the DIO data for this row. Due to analog propagation delays and digital filter delays that apply to analog channel data but not DIO data, this will be slightly different from the Time column.
- DIO – The input state of the 8 DIO channels as an 8-bit integer.

If channels are configured with differing values for RecordSize, then the columns for those channels with smaller values will have blank entries for the remaining rows of each record. If multiple records are saved in one file, the first row of the next record will be added directly after the last row of the previous record, *without* any marker or extra header row.

SECTION 7

ONBOARD MEMORY

ONBOARD MEMORY AND CLEARING PROCEDURE

The EX1403A family of instruments contains onboard memory which stores various information about the unit as well as data acquired. This section details the memory components and provides a procedure for clearing the memory.

Component	Volatile?	Contains	User Writeable?	Clear Procedure
2x32 MB Flash (MFG: Spansion P/N: S25FL256SAGNFI000)	No	Firmware	No	None
		File System	No	None
		Stored Instrument Configuration	Yes	Go to webpage, navigate to the **Nonvolatile Memory** page, check the **config** checkbox and press the Submit button.
		Network Configuration	Yes	
		Time Configuration	Yes	
2x512 MB DDR3 SDRAM (MFG: Micron Tech P/N: MT41K256M16HA-125 AAT:E)	Yes	Runtime Data	Yes	Power cycle machine
64KB FEEPROM (MFG: Atmel P/N: AT24C512C-XHM-T)	No	Main board model and serial number	No	None
		Main board factory full calibration	No	None
		Main board user full calibration	Yes	Go to webpage, navigate to the **Nonvolatile Memory** page, check the **main_full_cal** checkbox and press the Submit button.
64KB FEEPROM (MFG: Atmel P/N: AT24C512C-XHM-T)	No	Mezzanine board model and serial number	No	None
		Mezzanine board factory full calibration	No	None
		Mezzanine board user full calibration	Yes	Go to webpage, navigate to the **Nonvolatile Memory** page, check the **mezz_full_cal** checkbox and press the Submit button.

Table 7-1: Onboard Memory and Clearing Process

APPENDIX A

MULTIPLE INSTRUMENT SYSTEM

OVERVIEW

When a large number of measurement channels are required, multiple EX1403A instruments can be used synchronously. To achieve synchronized, simultaneous the data acquisition between instruments, both sampling clock and the measurement state machine transition must be synchronized. The EX1403A can utilize IEEE 1588-2008 and LXI LAN Event messages to accomplish this.

While the synchronization between instruments is automatically performed by instruments driver and is transparent to the user, it is important to understand the tradeoffs and limitations.

MASTER AND SLAVE

Regardless of synchronization method, one of the instruments becomes a master and others become slaves. The trigger state machine transition is paced by a master instrument and all slave instruments follow it. Because of this, arm and trigger events are only detected by the master instrument. The analog trigger signal, External trigger, DIO or LAN arm or trigger event must be sent to a master chassis.

The first chassis in the resource string becomes a master by default. However, when any analog channel or external trigger is enabled as an arm or trigger source, the instrument that contains the channel automatically becomes master. It is invalid configuration to enable arm or trigger channels from more than one instrument at the same time.

SYNCHRONIZATION PERFORMANCE

The variance of instrument-to-instrument phase matching largely depends on the network topology. The quality of network switches, amount of network traffic, and the stability of master clock each greatly affect the actual synchronization performance, or phase error. A dedicated network for the test system with a stable GPS Grandmaster clock (PTP v2), connected with boundary/transparent clock switches[1] provides the best and the most consistent performance. With a fully IEEE 1588-2008 aware infrastructure, it is possible to achieve typical (2σ) variance of less than ±20 ns.

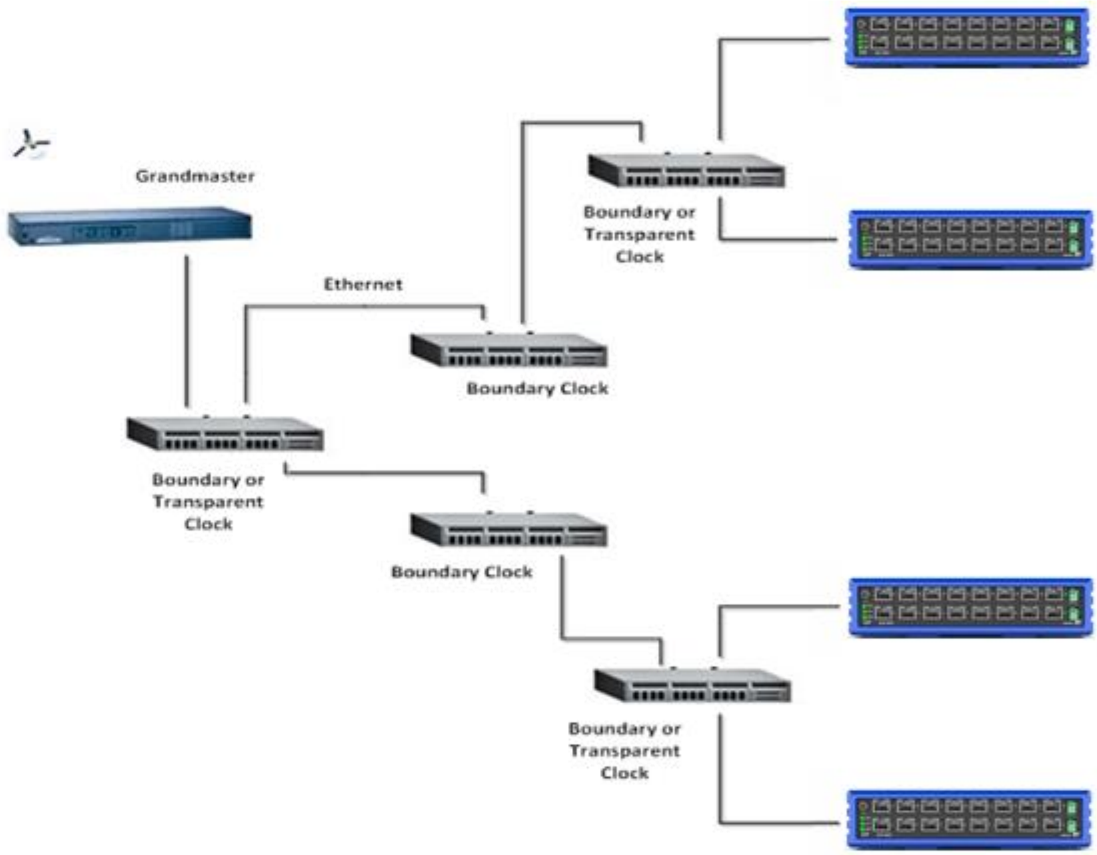


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Figure A-1: IEEE1588 Network Topology

APPENDIX B

DIGITAL DECIMATION FILTERS

OVERVIEW

The EX1403A's filter chain is designed to give users flexibility for usage in various applications that are constrained by either sample rates, group delays, anti-alias rejection, passband ripple or stopband attenuation. The basic block diagram of the filter chain is shown below.

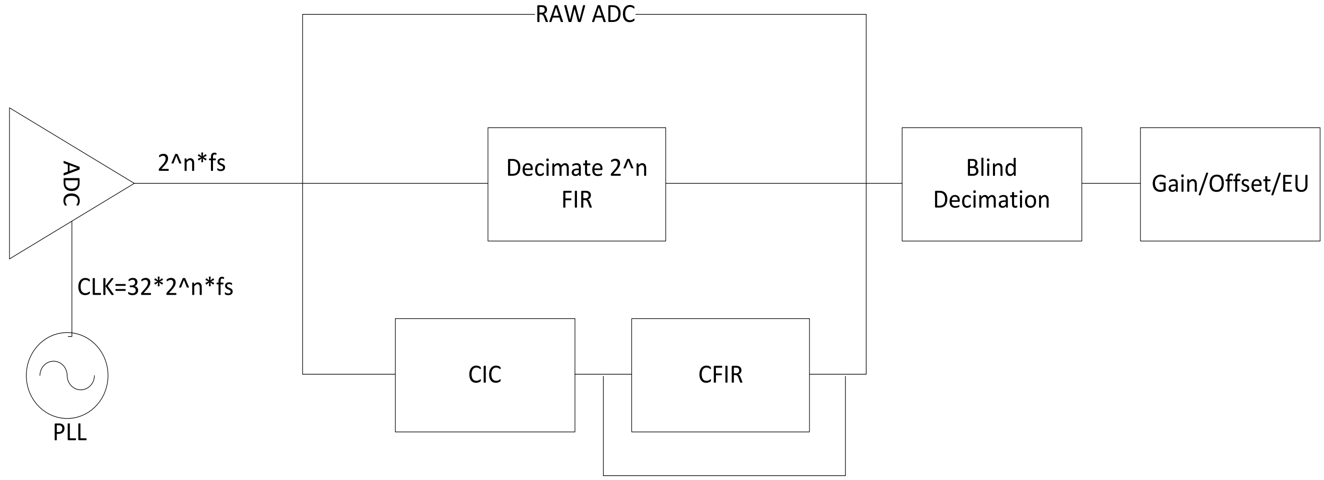

Figure B-1: -: FIR Response

PLL

The PLL clocks the sigma-delta converter and ultimately controls the output sample rate. The following table maps the PLL sample clock to the sample rate of the ADC.

ADC output rate in Hz	PLL rate in Hz
19531.25	10,000,000
65536, 32768	16,777,216
78125, 39062.5	20,000,000
100000, 50000	25,600,000
102400, 51200	26,214,400
128000, 64000	32,768,000

FILTER

There are four possible filter paths

1. High performance; i.e. a cascade of 16 stages of decimate by 2 FIR filters
2. Low latency; i.e. the CIC only path
3. Medium latency; i.e. CIC+CFIR
4. None (Bypass)

Each of these paths are followed by a blind decimation path that can be configured to throw all but 1 out of every 1-65536 samples.

HIGH PERFORMANCE

This filter path is a cascade of up to 16 decimate by 2 FIR filter paths. It has high stopband attenuation, very low passband ripple, and high group delay (especially when multiple stages of the filter are enabled). The filter coefficients can be customized via an API outlined below. The output sample rate is limited to the ADC output rate divided by 2^n.

Characteristics:
Passband = 0.39fs,
Stopband attenuation = 120dB
Passband ripple<0.0001dB

n	Group delay at output samples
1	15.7500
2	23.6250
3	27.5625
4	29.5313
5	30.5156
6	31.0078
7	31.2539
8	31.3770
9	31.4385
10	31.4692
11	31.4846
12	31.4923
13	31.4962
14	31.4981
15	31.4990
16	31.4995

As an example, the group delay is 31.377 samples at the output of the filter when invoking 8 stages. When used with an ADC output rate of 65536 Sps, the group delay is 31.377/(65536/2^8)=122.57ms. The settling time is twice the group delay.

The filter response plots are shown below:

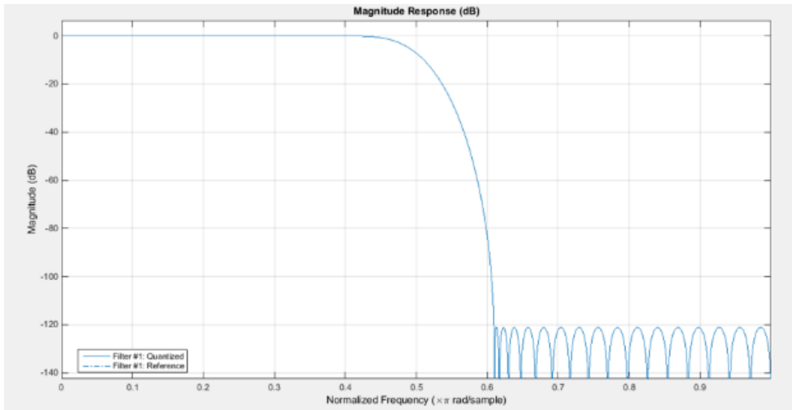

Figure B-2: -: FIR Response

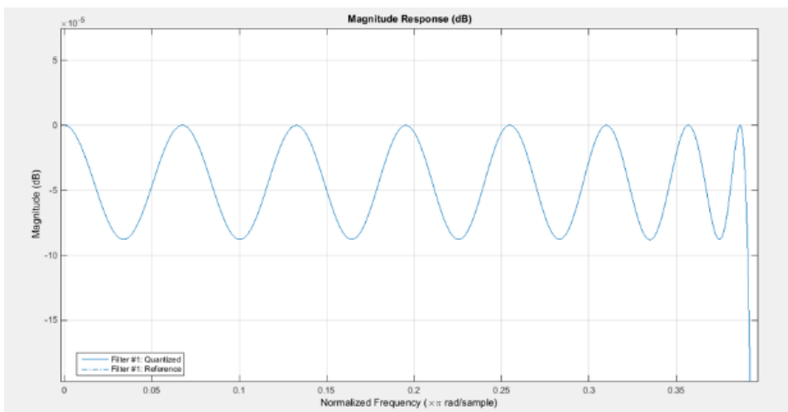

Figure B-3: - Zoomed in to show passband ripple

LOW LATENCY (CIC FILTER ONLY)

The CIC is a cascaded integrator comb decimation filter. It decimates the incoming samples by a programmable factor of 4-8192 with anti-aliasing. It has the structure shown below with M=1 & N=5. When used by itself i.e. without the CFIR (compensating FIR), it has excellent anti-alias rejection, excellent group delay but a narrow passband. This filter is ideal if you are doing DC or low frequency measurements.

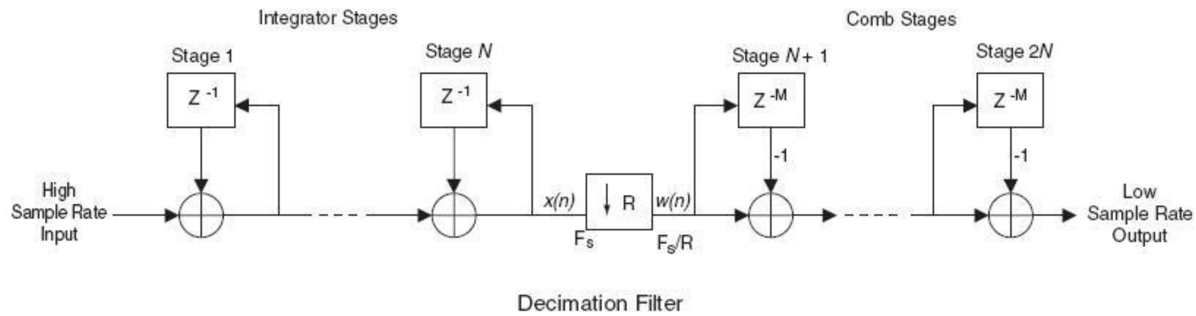

Figure 3.35: CIC Decimation Filter.

SOURCE: E. B. Hogenauer, "An Economical Class of Digital Filters for Decimation and Interpolation," [38]. © IEEE, 1981. Used by Permission.

Characteristics:

Group delay at CIC input rate = (R*M-1)*N/2 samples
So, for example, if the ADC output rate is 65536Hz and CIC decimation is 256 (R), the group delay is (256*1-1)*5/2=637.5 samples at the ADC output rate of 65536Hz = 9.73ms
Graphs for the CIC response is shown following the CFIR section

MEDIUM LATENCY (CIC + CFIR FILTER)

The medium latency filter consists of the CIC filter outlined above with an additional decimate by 4 FIR that corrects for the droop in the CIC output making it usable for AC measurements. The CFIR (CIC compensating FIR) coefficients can be customized using the API outlined below.
Characteristics:
Passband = 0.334fs (passband ratio = 1/3),
Stopband attenuation = 100dB
Passband ripple<0.005dB
Group delay:

- For CFIR only = (64-1)/2= 31.5 samples at input rate of CFIR
- For CIC+CFIR = (R*M-1)*N/2 + R*31.5 at input rate of CIC. So for example, for ADC output rate of 65536Hz, CIC decimation of 64 and CFIR decimation of 4, group delay = (64*1-1)*5/2 + 64*31.5=2173.5 samples at CIC input rate of 65536Hz i.e. 33.16ms

The following graphs illustrate graphically the response of the CIC only and CIC+CFIR response. Assume ADC output frequency =10KHz, CIC decimation (R)=100, CFIR decimation=4 i.e. User frequency = 25Hz

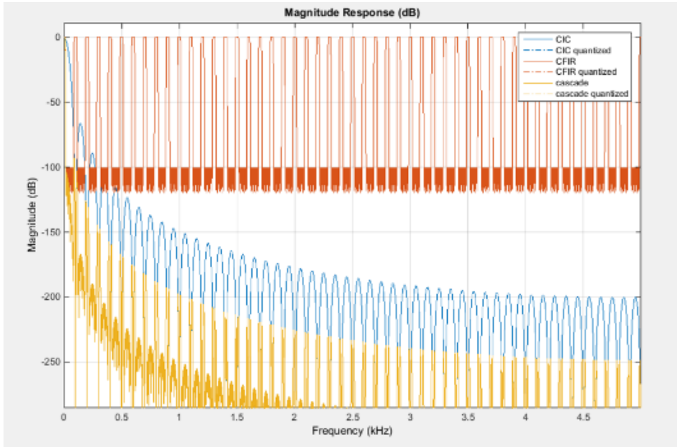

Figure B-4: - CIC/CFIR Filter response up to ADC Nyquist

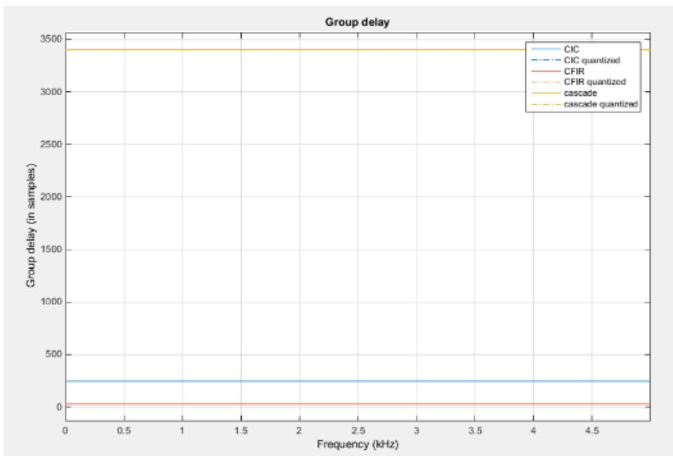

Figure B-5: - CIC/CFIR Group delay

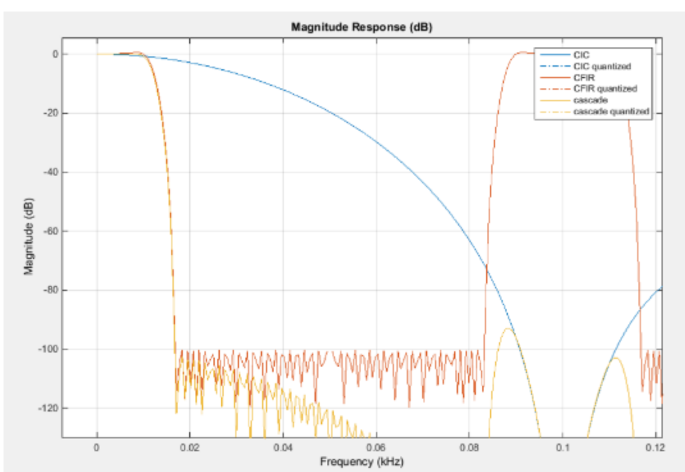

Figure B-6: - Zoomed CIC/CFIR Response

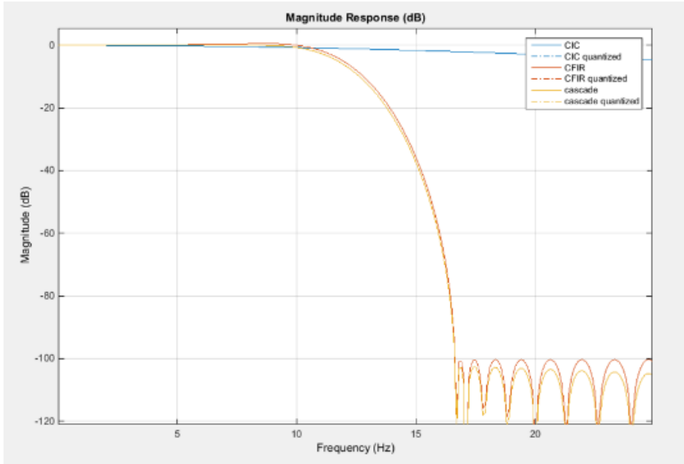

Figure B-7: - further Zoomed CIC/CFIR Response

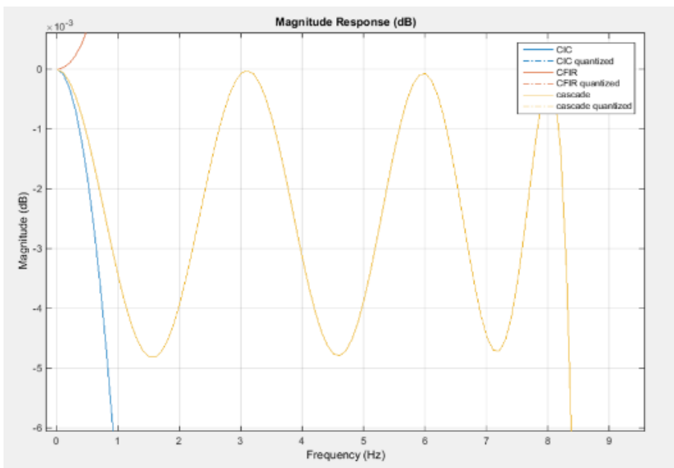

Figure B-8: -EVEN further Zoomed CIC/CFIR Response

BLIND DECIMATION

Blind decimation entails picking 1 out of 1-65536 samples. Users can avail of this feature to get to very low sample rates with minimal latency with no anti-alias protection.

USER API

The APIs for configuring the filters and sample rate, global for all channels, are outlined below. Use caution when exercising the APIs since the order in which you invoke them will determine the final sample rate.

IVTEXDigitizerMeasurementSampling.ClockFrequency

The PLL and ADC are configured such that the ADC Output Data Rate will equal the value of this property.

IVTEXDigitizerMeasurementSampling.FilterType

Selects between the four filter options: High Performance, Medium Latency, Low Latency, or None.

The selected Decimation Ratio for each value of Filter Type is configured in the firmware separately. When changing Filter Type, the Sample Rate and Span will change to reflect the Decimation Ratio last used with the new Filter Type.

IVTEXDigitizerMeasurementSampling.DownsamplingFactor

The amount of blind decimation

IVTEXDigitizerMeasurementSampling.SampleRate

The value of this property is the final output data rate of the selected filter with the blind decimation i.e. the final output rate of the channel. Setting it has the effect of configuring the Decimation Ratio of the selected filter to the best value that can achieve that rate (or the next closest higher rate if the exact specified rate is not possible).

Sample Rate is equal to (Clock Frequency / Decimation Ratio) / Downsampling Factor. Decimation Ratio can only be changed by setting Sample Rate or Span. When changing either Clock Frequency or Downsampling Factor, Decimation Ratio remains constant and the value of Sample Rate changes according to this formula. For that reason, it is normally advised to set all other properties first, then set Sample Rate last, to the final data rate desired.

Regardless of the value of Filter Type, if Sample Rate is set equal to Clock Frequency, the Bypass filter path will be selected, setting the Decimation Ratio to 1.

IVTEXDigitizerMeasurementSampling.Span

This property performs the same function as Sample Rate, but instead of describing the output data rate, it describes the highest frequency data signal that can be detected with the selected sample rate and other settings. Its value is always equal to Sample Rate * Passband Ratio.

Because the Low Latency filter is only appropriate for DC inputs, this property is not usable when that filter is selected.

IVTEXDigitizerMeasurementSampling.SetFilterCoefficients()

Configures the 64 normalized filter coefficients for the selected filter (FIR or CFIR only).

IVTEXDigitizerMeasurementSampling.GetFilterCoefficients()

Retrieves the 64 normalized filter coefficients for the selected filter (FIR or CFIR only).

IVTEXDigitizerMeasurementSampling.GroupDelay

The amount group delay, in input samples, of a single stage of the currently selected Filter Type (FIR or CFIR only). This value is updated automatically when Filter Type is changed. If SetFilterCoefficients() is used to specify custom filter behavior, this can be set by the user to ensure the firmware corrects data timestamps properly.

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