VTI Instruments

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EX1401

16-CHANNEL ISOLATED THERMOCOUPLE AND VOLTAGE MEASUREMENT INSTRUMENT

FEATURES

- 16-channel isolated universal thermocouple/voltage inputs
- 24-bit ADC per channel
- Typical accuracies of 0.02% of Reading
- 500 V channel-ground isolation
- 1000 V channel-channel isolation
- 20K samples/second/channel sample rate
- Data logger acquisition mode
- Power over Ethernet PoE+ or 10–50 V DC input
- Built-in parallel data streaming
- Full-featured embedded web interface
- LXI Ethernet interface
- 8-bit bank isolated digital I/O
- Compact 1U half-rack form factor

APPLICATIONS

- Battery and fuel cell test
- Thermal data acquisition
- Gas turbine test
- HALT/HASS
- In-vehicle automotive test
- Electric motor test
- Wind tunnel evaluation
- Rocket motor reliability
- Health monitoring

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EX1401

Precision, Isolated Temperature Measurements

The AMETEK VTI Instruments EX1401 adds isolation and high-speed measurement capability to the popular EX1000 Series of instruments, an advanced, full-featured data acquisition family designed to acquire precision data from temperature and voltage sensors.

The EX1401 delivers accurate and highly repeatable thermocouple (±0.20°C) and voltage measurements by implementing fully integrated signal conditioning, 24-bit ADC's, and independent Cold Junction Compensation (CJC) on a per-channel basis.

With industry-leading sample rates of 20 kSa/s/channel, the EX1401 is well-suited for a wide range of applications that require maximum accuracy, flexible sampling rates, and protection against damaging voltage levels.

Enhanced power options, including AC, DC, and PoE, adapt to virtually any application requirement while the stand-alone data logging and parallel data streaming capabilities break new ground for performance and flexibility.

Scalable for High-Speed Synchronized Data Acquisition

In addition to the core set of features, the EX1401 integrates Extended Functions as defined in the LXI specifications to provide box-to-box synchronization to precisely correlate acquired data as well as time-stamping of data and LAN
Event Messaging that facilitate intermodule communication and flexible triggering options over Ethernet, thereby eliminating overhead normally attributed to application software running on the host controller.

The EX1401 supports easy integration and synchronization of multiple devices through the IEEE-1588 v2 Precision Time Protocol standard for synchronization, providing an architecture that can be scaled from 10s to 1000s of channels. Multiple boxes can be easily distributed extremely close to the measurement points of interest reducing the run length of analog cable and minimizing errors induced by noisy environments. Additionally, a Power Over Ethernet (PoE) enables a single cable to be used for both power and data capture. All measurement data is returned with IEEE-1588 timestamp codes with typical accuracies of <200nS ensuring that acquired data is tightly correlated across the test article.

Cold Junction Compensation (CJC)

The heart of any truly accurate thermocouple measurement system is the CJC implementation. The EX1401 is designed to measure the actual cold junction temperature at the point where the dissimilar metals meet. To further ensure the precision of the data, each channel has its own dedicated CJC sensor to reduce errors associated with temperature gradients across the box.

Self-Test

Manufacturing and test environments of today are dynamic, dictating minimal downtime of test systems in order to meet increasing product throughput demands. Ensuring that acquired data is reliable and instrument calibration can be turned around quickly are keys to the success of any production team. VTI embeds intelligence into the EX1401 to facilitate maximum system 'uptime' and increase manufacturing efficiency.

Built-in self-test can be invoked under software control prior to each critical test. A simple pass-fail result will be returned after completing system health diagnostics, including temperature and voltage level measurements of the on-board processor and can be used to prevent a test from running in the event of a failure.

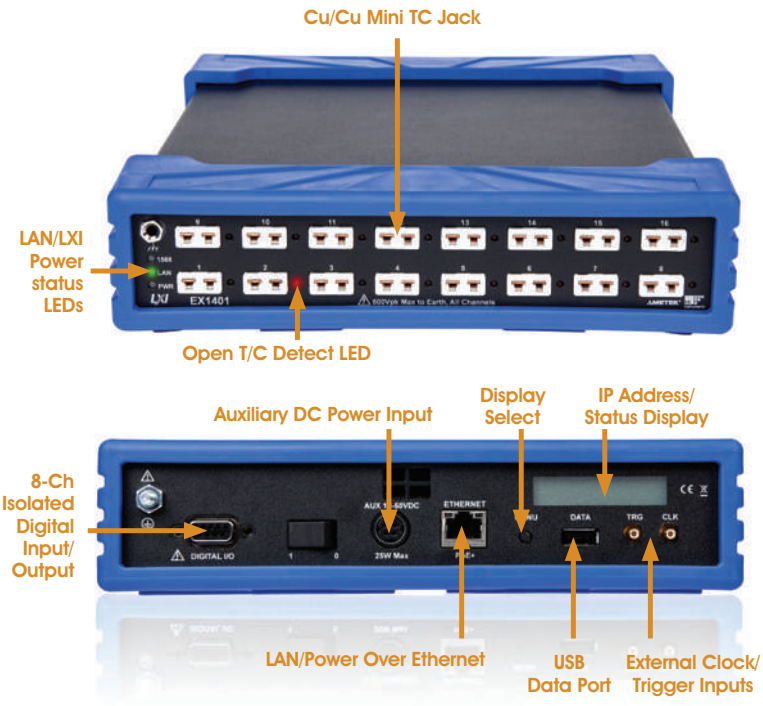
Open Thermocouple Detection (OTD) circuitry is incorporated and gives continuous visual indication via an LED whenever a broken transducer link is detected. OTD conditions can also be configured in the application through the supplied API and can be activated/deactivated on a per-channel basis.

LXI – The Industry Standard for Ethernet Instrumentation

Created in 2004 and adopted by the test and measurement industry in 2005, LXI (LAN Extensions for Instrumentation) defines a core set of capabilities that ensure compliant devices interact consistently in an instrumentation network. As an LXI-certified device, the EX1401 provides the convenience of LAN communications and control with features such as an embedded web page for monitor and control and a consistent means of identification on the network. Connect the device directly to your network using industry-standard cables with the assurance that it will be a trusted and proven 'network citizen'.

Isolated Measurements

Challenging measurement environments such as areas with a high level of electrical noise or where transient power surges can occur require unique protection capabilities in order to safeguard against common-mode noise or ground loop problems. The EX1401 provides exceptional input protection and isolation across a wide range of operating conditions, protecting the instrument from harmful voltages while ensuring measurement integrity. The Ethernet communications interface and input power are isolated from the analog front end inputs.



General Specifications

Channels	**Analog**	16 differential inputs, programmable type on per-channel basis, isolated	
	Digital (Input/Output)	8 single-ended, 5 V TTL, bank isolated	
Channel Types		Thermocouple inputs: J, K, T, E, S, R, B, N	
		Voltage inputs: mV, V	
Sampling Rate		The EX1401 is designed for sampling speeds up to a 20 kSa/s per channel, regardless of the number of enabled channels. The lowest sampling speed is 0.000002328 Hz (approximately one sample every 5 days.)	
Isolation, Analog	**Channel-Ground**	500 V	
	Channel-Channel	1000 V	
Isolation, Digital	**Channel-Ground**	250 V	
	Channel-Channel	N/A (BANK ISOLATED)	
Programmable Digital Filters	**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)	
Voltage Input Range	**Voltage Input Mode**	±0.01 V, ±0.10 V, ±1.0 V, ±10.0 V	
	Thermocouple Input Mode	±0.10 V for temperature measurement	
Input Protection		100 V Normal mode protection	
Input Impedance (typical)		20 M differential (DC input)	
		1.7 M differential (60 Hz input)	
		180 k differential (1000 Hz input)	
Input Bias Current		5 nA typical	
Voltage Resolution	**±10.0 V**	1.7 µV	
	±1.0 V	150 nV	
	±0.1 V	13.5 nV	
	±0.01 V	1.7 nV	
Accuracy	**Voltage Mode**	± (% of reading + offset), see Conditions for Accuracy	
	±10.0 V	Typical: ± (0.020% + 400uV)	Max: ± (0.030% + 500uV)
	±1.0 V	Typical: ± (0.020% + 40uV)	Max: ± (0.030% + 50uV)
	±0.1 V	Typical: ± (0.020% + 7uV)	Max: ± (0.035% + 15uV)
	±0.01 V	Typical: ± (0.050% + 5uV)	Max: ± (0.145% + 9uV)
	Thermocouple Mode		
	Type J, K, T, E, N	Typical: ± (0.020% + 0.2°C)	Max: ± (0.040% + 0.4°C)
	Type S, R	Typical: ± (0.020% + 0.6°C)	Max: ± (0.040% + 1.3°C)
	Type B	Typical: ± (0.020% + 0.9°C)	Max: ± (0.040% + 1.8°C)
Stability	**Voltage Mode**		
	±10.0 V	Typical: ± (5PPM/°C + 1.20uV/°C)	Max: ± (9PPM/°C + 2.7uV/°C)
	±1.0 V	Typical: ± (5PPM/°C + 0.12uV/°C)	Max: ± (9PPM/°C + 0.27uV/°C)
	±0.1 V	Typical: ± (5PPM/°C + 0.08uV/°C)	Max: ± (9PPM/°C + 0.16uV/°C)
	±0.01 V	Typical: ± (9PPM/°C + 0.08uV/°C)	Max: ± (14PPM/°C + 0.16uV/°C)
	Thermocouple		
	Type J, K, T, E, N	Typical: ± (8PPM/°C + 0.006°C/°C)	Max: ± (14PPM/°C + 0.012°C/°C)
	Type S, R	Typical: ± (8PPM/°C + 0.020°C/°C)	Max: ± (14PPM/°C + 0.040°C/°C)
	Type B	Typical: ± (8PPM/°C + 0.030°C/°C)	Max: ± (14PPM/°C + 0.060°C/°C)

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Table 1-1: Thermocouple Typical Accuracy (°C)

Type	Min	Max	-100°C	0°C	100°C	300°C	500°C	700°C	900°C	1100°C	1400°C
J	-200°C	1200°C	±0.30°C	±0.20°C	±0.20°C	±0.30°C	±0.30°C	±0.30°C	±0.40°C	±0.40°C	—
K*	-200°C	1372°C	±0.30°C	±0.30°C	±0.30°C	±0.30°C	±0.40°C	±0.40°C	±0.50°C	±0.50°C	±0.60°C
T**	-200°C	400°C	±0.40°C	±0.30°C	±0.20°C	±0.30°C	±0.30°C	—	—	—	—
E	-200°C	900°C	±0.30°C	±0.20°C	±0.20°C	±0.20°C	±0.30°C	±0.30°C	±0.30°C	—	—
S	-50°C	1768°C	—	±1.40°C	±1.00°C	±0.90°C	±0.90°C	±0.90°C	±0.90°C	±0.90°C	±0.90°C
R	-50°C	1768°C	—	±1.40°C	±1.00°C	±0.80°C	±0.80°C	±0.80°C	±0.80°C	±0.80°C	±0.80°C
B	250°C	1820°C	—	—	—	±2.40°C	±1.60°C	±1.20°C	±1.10°C	±1.00°C	±1.00°C
N	-200°C	1300°C	±0.40°C	±0.30°C	±0.30°C	±0.30°C	±0.40°C	±0.40°C	±0.40°C	±0.50°C	—

Table 1-2: Thermocouple Maximum Accuracy (°C)

Type	Min	Max	-100°C	0°C	100°C	300°C	500°C	700°C	900°C	1100°C	1400°C
J	-200°C	1200°C	±0.50°C	±0.40°C	±0.40°C	±0.50°C	±0.50°C	±0.60°C	±0.60°C	±0.70°C	—
K*	-200°C	1372°C	±0.60°C	±0.50°C	±0.50°C	±0.60°C	±0.60°C	±0.70°C	±0.80°C	±0.90°C	±1.00°C
T**	-200°C	400°C	±0.70°C	±0.50°C	±0.40°C	±0.40°C	±0.50°C	—	—	—	—
E	-200°C	900°C	±0.40°C	±0.30°C	±0.30°C	±0.40°C	±0.40°C	±0.50°C	±0.60°C	—	—
S	-50°C	1768°C	—	±2.90°C	±2.20°C	±1.80°C	±1.80°C	±1.70°C	±1.70°C	±1.70°C	±1.80°C
R	-50°C	1768°C	—	±2.90°C	±2.10°C	±1.70°C	±1.60°C	±1.60°C	±1.50°C	±1.50°C	±1.60°C
B	250°C	1820°C	—	—	—	±5.10°C	±3.20°C	±2.50°C	±2.20°C	±2.00°C	±1.90°C
N	-200°C	1300°C	±0.80°C	±0.70°C	±0.60°C	±0.60°C	±0.60°C	±0.70°C	±0.80°C	±0.90°C	—

Conditions for Temperature Accuracy and Voltage Accuracy

- 30-minute warm-up after turn ON and TC plug connected. 10 SPS acquisition rate, Low Latency CIC filter
- 20 °C to 30 °C, 1 year from full calibration. Typical is defined as ± 2*Sigma (95% confidence)
- Fan must be ON. Add ±0.22°C to Typical, or ±0.34°C to Maximum if FAN is OFF
- Exclusive of externally induced noise, Common Mode Voltages (CMV), thermocouple and cable length errors

* 1400 accuracy is for 1372°C
** 500 accuracy is for 400°C

Noise Levels (Typical)

Sample Rate	10 V	1 V	100 mV	10 mV	Temp (type T at 25°C)
10,000	900 uVpp	60 uVpp	14.0 uVpp	13.0 uVpp	0.34°C pp
1,000	200 uVpp	13 uVpp	3.0 uVpp	2.5 uVpp	0.08°C pp
100	60 uVpp	4 uVpp	1.0 uVpp	0.8 uVpp	0.04°C pp
10	20 uVpp	1.5 uVpp	0.5 uVpp	0.33 uVpp	0.03°C pp

General Specifications (continued)

Isolation – Analog Inputs	Basic insulation, IEC 61010-1 (3rd): Pollution degree II, Material IIIa, Altitude < 5000 m, Overvoltage Category II, applicable for secondary circuits derived from the Mains	
	Input channel to Ground	±500 V Peak continuous working voltage
	Input channel to channel	±1000 V Peak continuous working voltage between channels
	Impedance across barrier	100 pF II Gas Discharge Tube rated for 600 V

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General Specifications (continued)

Common Mode Input Range	500 V peak with respect to earth ground				
Common Mode Rejection Ratio (CMRR) (typical)		**DC**	**50/60 Hz**	**400 Hz**	**1000 Hz**
	10mV range	-140 dB	-140 dB	-130 dB	-110 dB
	100mV range	-140 dB	-140 dB	-130 dB	-90 dB
	1V range	-140 dB	-140 dB	-130 dB	-80 dB
	10V range*	-140 dB	-140 dB	-130 dB	-80 dB
	The 10V input range is reduced by increasing common mode AC voltage above 100Vpk/60Hz.				
Channel-to-Channel Crosstalk (typical)	-145 dB < 1 kHz				
Total Harmonic Distortion (THD) (typical)		**100 Hz full scale input**			
	100 mV range	-85 dB			
	1 V range	-87 dB			
	10 V range	-90 dB			
Host controller Connection	10/100 Base-T INPUT CONNECTOR, RJ45				
Input Power	**Input voltage:** 10 V to 50 V DC, must be isolated to 1500 Vrms				
	Power (AUX): 12 W typical, 15 W max				
	PoE+ Power: 12 W typical, 15 W max				
Dimensions (XE "Dimensions")	1.68" H x 8.69" W x 10.00" D (all dimensions are in inches)				
Weight	4.7 lbs (2.1 kg)				

Specifications subject to change without notice.

* The 10 V input range will be reduced by increasing common mode AC voltage beyond 100 Vpk/60 Hz

Synchronization Specifications

Specifications	**Clock Oscillatory Accuracy**	±20 PPM
	Synchronization Accuracy	Reports "Synchronized" When <+/- 300 nS of the 1588 Master Clock Timestamp
	Accuracy	As good as time synchronization down to 40 nS resolution, 40 nS
IEEE 1588-Based Trigger Timing	**Alarm**	**Trigger Time Accuracy:** As good as time synchronization Down to 40 nS Time to Trigger Delay 40 nS
	Receive LAN [0-7] Event	**Trigger Time Accuracy:** As good as time synchronization Down to 40 nS Time to Trigger Delay
	Future Timestamp	40 nS typical past/zero timestamp 1 mS maximum
Hardware Trigger Timing Digital I/O	**Bus**	Time to trigger delay Min: 50 nS, Max: 100 nS

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DI/O Specifications

Number of DI/O Channels		8
Electrical Specifications	**Maximum Input Voltage**	-0.5 V to 5.5 V, ESD protected
	Input Impedance	Signal is pulled low by a 10k Ohm resistor
	Minimum Input Pulse Width	100 μs
	Minimum Output Pulse Width	100 μs, updated synchronously with the ADC sampling, prior to decimation
	V_{IL}	< 0.8 V
	V_{IH}	> 2.0 V
	V_{OL}	< 0.55 V @ 10 mA
	V_{OH}	> 2.0 V @ 10 mA
	I_{MAX}	10 mA max per channel, 20 mA max per bank
Isolation – Digital	Basic insulation, IEC 61010-1 (3rd): Pollution degree II, Material IIIa, Altitude < 5000 m, Overvoltage Category II, applicable for secondary circuits derived from the Mains	
	Input channel to Ground	±250 V Peak continuous working voltage
	Input channel to channel	None, all channels share one ground pin
	Impedance across barrier	1000 pF ll 10 M ll Gas Discharge Tube rated for 600 V
Connector		9-pin standard D-Sub Female socket

Environmental Specifications

Temperature (Operating)		0°C TO +50°C
Humidity (Operating)		5% to 95% (non-condensing)
Altitude		Up to 4600 M
Shock and Vibration Conforms to MIL-PRF-28800F	**Random Vibration**	10 min per axis, MIL-PRF-28800F Class 3
	Sinusoidal	5 to 55 HZ resonance search per MIL-PRF-28800F Class 3, each axis shock 30 G/axis, 11 MS half sine pulse per MIL-PRF-28800F Class 3

Ordering Information

Model Part Number	Model and Description
70-0626-000R	EX1401 16-Channel Isolated Thermocouple and Voltage Measurement Instrument
56-0739-120R	EX14XX AC/DC Power Supply, 120W, PSE Certified
56-0739-000R	EX14XX AC/DC Power Supply 60W
70-0626-900R	EX14XX-RK001, Rack Mount Kit
41-0620-015R	EX14XX Rack Mount Filler Panel

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