

# USB-2408 Series

## 24-Bit Multifunction Temperature & Voltage Devices



### Features

- Measure thermocouples (TCs) or voltage
- Up to 16 analog inputs
- 24-bit resolution
- Up to 1 kS/s sampling
- 8 digital I/O
- Two counters
- Up to 2 analog outputs
- 500 VDC isolation between field wiring and the USB interface

### Software

- TracerDAQ® software included for acquiring and displaying data and generating signals
- Universal Library includes support for Visual Studio® and Visual Studio®.NET, including examples for Visual C++®, Visual C#®, Visual Basic®, and Visual Basic® .NET
- DAQFlex open-source software framework; compatible with Windows® 32/64, Linux®, and Mac® platforms
- Comprehensive drivers for DASyLab® and NI LabVIEW™
- InstaCal software utility for installing, calibrating, and testing

### Overview

The USB-2408 Series are multifunction DAQ devices designed for highly-accurate voltage or temperature measurements. Each device features up to 16 single-ended (SE)/8 differential (DIFF) analog inputs. Each device includes 8 digital I/O and two counter inputs. The USB-2408-2AO also features two analog outputs. Each device in the series offers 24-bit resolution for ultra-accurate voltage or TC measurements.

### Analog Input

Each device includes 16 SE/8 DIFF analog inputs which you can configure for voltage or TC input on a per-channel basis. Eight software-selectable voltage input ranges are provided. You can configure these ranges on a per-channel basis from  $\pm 10$  V to  $\pm 0.078$  V. When measuring TCs, configure analog inputs in DIFF mode. All devices also include open TC detection to identify improperly working thermocouples.



USB-2408 Series devices offer high-resolution voltage or thermocouple measurements along with digital I/O and counter inputs. The USB-2408-2AO (shown here) includes analog output functionality.

| USB-2408 Series Selection Chart |               |                 |                |             |          |
|---------------------------------|---------------|-----------------|----------------|-------------|----------|
| Model                           | Analog Inputs | Throughput Rate | Analog Outputs | Digital I/O | Counters |
| USB-2408                        | 16 SE/8 DIFF  | Up to 1 kS/s    | —              | 8           | 2        |
| USB-2408-2AO                    | 16 SE/8 DIFF  | Up to 1 kS/s    | 2              | 8           | 2        |

### Sample Rate

USB-2408 Series devices can sample analog input channels at up to a 1 kS/s.\*

### Digital I/O

Eight digital I/O channels are included with each USB-2408 Series device, and you can read from or write to each individual bit.

### Counters

Two 32-bit counters are included with USB-2408 Series devices. The TTL level inputs are capable of read/write rates of up to 500 Hz and an input frequency of up to 1 MHz.

### Analog Output (USB-2408-2AO only)

The USB-2408-2AO includes two 16-bit analog outputs. Each output has a  $\pm 10$  V range. Both outputs can be updated at a rate of up to 500 S/s per channel; one output can be updated at a rate of 1 kS/s.

### Software

Each USB-2408 Series device includes TracerDAQ, an out-of-the-box application that generates, acquires, analyzes, displays, and exports data within seconds of installing Measurement Computing data acquisition hardware. TracerDAQ includes a Strip Chart, Oscilloscope, Function Generator, and Rate Generator, all of which are accessed through a common, easy-to-use menu page.

Driver support and detailed example programs are included for Universal Library programming libraries for Microsoft® Visual Studio® programming languages, and other languages, including DASyLab®, and ULx for NI LabVIEW®.

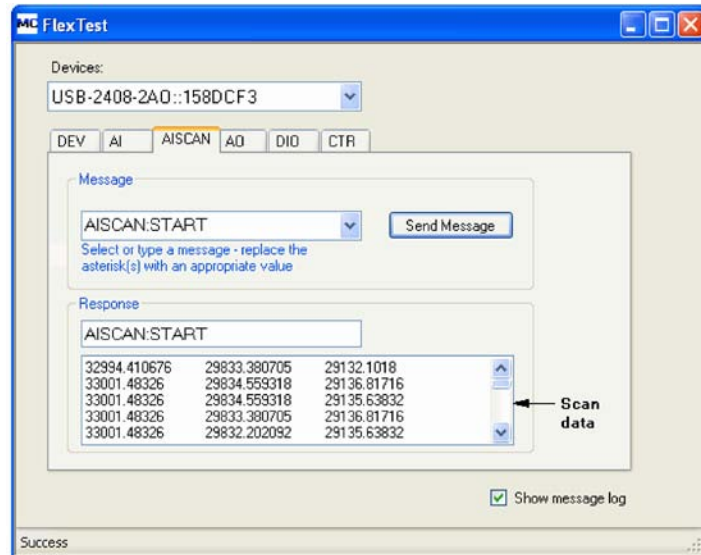
\* Refer to the section, *Noise filtering, data rate, and throughput rate*, in the *USB-2408 Series User's Guide* to learn how the USB-2408 Series noise filtering feature affects the throughput rate for analog inputs.

# USB-2408 Series

## General Information & Specifications

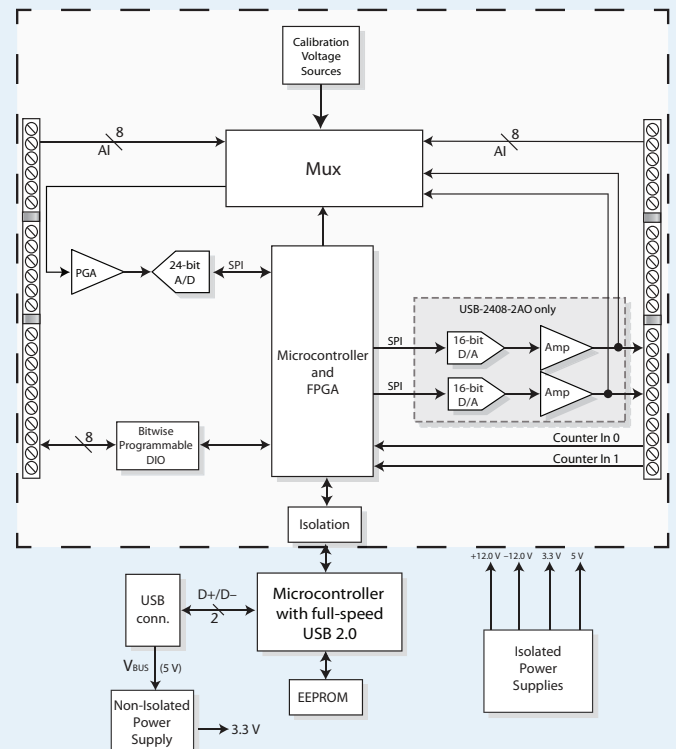
### DAQFlex

For DAQ programming in virtually any OS, USB-2408 Series devices include DAQFlex, a framework that combines a small footprint driver with a message-based command protocol. The simplicity of the driver is enabled with a message-based protocol that offers an efficient yet powerful interface to DAQ devices and a common command set that simplifies application development.



FlexTest is an interactive GUI-based utility that demonstrates how to communicate with a device using the DAQFlex communication protocol and software.

### USB-2408 Series Block Diagram



## Specifications

All specifications are subject to change without notice.  
Typical for 25 °C unless otherwise specified.  
All specifications apply to all temperature and voltage input channels unless otherwise specified.

### Analog Input

**A/D Converter Type:** ADS1256, 24-bit Sigma Delta  
**A/D Data Rates:** 3750 S/s, 2000 S/s, 1000 S/s, 500 S/s, 100 S/s, 60 S/s, 50 S/s, 25 S/s, 10 S/s, 5 S/s, 2.5 S/s  
**Throughput (Software-Selectable for Single Channel and Multiple Channels)**  
**Single Channel:** 2.5 S/s to 1102.94 S/s  
**Multiple Channels:** 0.16 Hz to 1102.94 Hz  
**Number of Channels:** Up to 16 channels individually software-selectable as SE or DIFF; TCs require differential mode; for each channel configured as differential, you lose one single-ended channel  
**Input Isolation:** 500 VDC min between field wiring and USB interface  
**Channel Configurations:** Temperature sensor input, software-selectable to match sensor type; voltage input  
**Input Voltage Range**  
**Thermocouple Mode:**  $\pm 0.078125$  V  
**Voltage Mode\* (Software-Selectable):**  $\pm 10$  V,  $\pm 5$  V,  $\pm 2.5$  V,  $\pm 1.25$  V,  $\pm 0.625$  V,  $\pm 0.3125$  V,  $\pm 0.15625$  V,  $\pm 0.078125$  V  
**Absolute Maximum Input Voltage**  
**CxH-CxL relative to GND:**  $\pm 22$  V max (power on),  $\pm 10$  V max (power off)

**Input Impedance:** 10 M $\Omega$  (power on), 390  $\Omega$  (power off)  
**Input Leakage Current**  
 $\pm 20$  nA  
**Input Voltage  $> \pm 22$  V (Power On/Off):**  $\pm 1$   $\mu$ A max  
**Input Capacitance:** 590 pf  
**Maximum Working Voltage (Signal + Common Mode)**  
**Voltage Mode:**  $\pm 10.25$  V max  
**Common Mode Rejection Ratio**  
**Thermocouple Mode ( $f_{IN} = 60$  Hz):** 110 dB  
**Voltage Mode ( $f_{IN} = 60$  Hz, all input ranges):** 90 dB  
**ADC Resolution:** 24 bits  
**Crosstalk:** Adjacent channels, 100 dB  
**Input Coupling:** DC  
**Channel Gain Queue:** Up to 64 elements, software-selectable channel and range  
**Warm-Up Time:** 45 minutes min  
**Open Thermocouple Detect:** Software-selectable for each channel  
**C/JC Sensor Accuracy**  
**15 °C to 35 °C:**  $\pm 0.5$  °C typ  
**0 °C to 55 °C:**  $\pm 1.0$  °C max

# USB-2408 Series

## Specifications



### Channel Configurations

CxH/CxL

**Thermocouple:** 8 DIFF channels

**Voltage:** 16 individually configurable channels that can be configured as either 16 SE or 8 DIFF

### Compatible Sensors (Thermocouple)

J: -210 °C to 1200 °C

R: -50 °C to 1768 °C

T: -270 °C to 400 °C

E: -270 °C to 1000 °C

K: -270 °C to 1372 °C

S: -50 °C to 1768 °C

N: -270 °C to 1300 °C

B: 0 °C to 1820 °C

| Thermocouple Accuracy Specifications*  |                          |                         |                         |                |
|--|--------------------------|-------------------------|-------------------------|----------------|
| Includes CJC Measurement Error and Polynomial Linearization Error                |                          |                         |                         |                |
| Specifications Valid for One Year or 3000 Operating Hours, Whichever Comes First |                          |                         |                         |                |
| Thermocouple   | Sensor temperature range | Accuracy error, maximum | Accuracy error, typical | Tempco (°C/°C) |
| J  | -210 °C                  | ±2.572 °C               | ±1.416 °C               | ±0.022         |
|  | 0 °C                     | ±0.935 °C               | ±0.469 °C               |                |
|  | 1200 °C                  | ±1.869 °C               | ±1.456 °C               |                |
| K  | -210 °C                  | ±2.917 °C               | ±1.699 °C               | ±0.029         |
|  | 0 °C                     | ±1.017 °C               | ±0.526 °C               |                |
|  | 1372 °C                  | ±2.478 °C               | ±2.022 °C               |                |
| N  | -200 °C                  | ±3.480 °C               | ±2.030 °C               | ±0.029         |
|  | 0 °C                     | ±1.201 °C               | ±0.659 °C               |                |
|  | 1300 °C                  | ±1.991 °C               | ±1.600 °C               |                |
| R  | -50 °C                   | ±4.826 °C               | ±3.133 °C               | ±0.082         |
|  | 250 °C                   | ±2.117 °C               | ±1.424 °C               |                |
|  | 1768 °C                  | ±2.842 °C               | ±2.347 °C               |                |
| S  | -50 °C                   | ±4.510 °C               | ±2.930 °C               | ±0.089         |
|  | 250 °C                   | ±2.165 °C               | ±1.468 °C               |                |
|  | 1768 °C                  | ±3.187 °C               | ±2.597 °C               |                |
| B  | 250 °C                   | ±5.489 °C               | ±3.956 °C               | ±0.14          |
|  | 700 °C                   | ±2.283 °C               | ±1.743 °C               |                |
|  | 1820 °C                  | ±2.202 °C               | ±1.842 °C               |                |
| E  | -200 °C                  | ±2.413 °C               | ±1.352 °C               | ±0.017         |
|  | 0 °C                     | ±1.069 °C               | ±0.551 °C               |                |
|  | 1000 °C                  | ±1.575 °C               | ±1.211 °C               |                |
| T  | -200 °C                  | ±2.821 °C               | ±1.676 °C               | ±0.027         |
|  | 0 °C                     | ±1.050 °C               | ±0.558 °C               |                |
|  | 400 °C                   | ±0.957 °C               | ±0.595 °C               |                |

\* Each terminal block has a CJC sensor. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. The accuracy errors do not include the inherent accuracy error of the TC sensor. Ask your TC supplier about the actual TC sensor accuracy limitations. Connect TCs to the USB-2408 Series device so that they float with respect to AGND. When configuring TC sensors, keep any stray capacitance relative to AGND as small as possible to avoid settling time and accuracy errors.

AGND and DGND pins are isolated from earth ground. To connect TC sensors to voltages referenced to earth ground, maintain isolation between the AGND/DGND pins and earth ground. To achieve the TC accuracies listed above, warm up the USB-2408 Series device for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the device is housed in the plastic enclosure.

# USB-2408 Series

## Specifications



| Analog Input DC Voltage Measurement Accuracy |                           |              |                        |                   |   |  |
|--|---------------------------|--------------|------------------------|-------------------|---|--|
| Range  | Gain error (% of reading) | Offset error | INL error (% of range) | Absolute accuracy | Gain temperature coefficient (% reading/°C) | Offset temperature coefficient (µV/°C) |
| ±10 V  | ±0.0037                   | 50 µV        | ±0.0008                | 500 µV            | ±0.0006                                     | 3                                      |
| ±5 V   | ±0.0047                   | 25 µV        | ±0.0008                | 300 µV            | ±0.0006                                     | 2                                      |
| ±2.5 V                                       | ±0.0059                   | 20 µV        | ±0.0008                | 200 µV            | ±0.0006                                     | 1                                      |
| ±1.25 V                                      | ±0.0056                   | 20 µV        | ±0.0008                | 100 µV            | ±0.0006                                     | 1                                      |
| ±0.625 V                                     | ±0.0068                   | 15 µV        | ±0.0005                | 60 µV             | ±0.0006                                     | 1                                      |
| ±0.3125 V                                    | ±0.0104                   | 15 µV        | ±0.0006                | 50 µV             | ±0.0006                                     | 1                                      |
| ±0.15625 V                                   | ±0.0184                   | 10 µV        | ±0.0005                | 40 µV             | ±0.0006                                     | 1                                      |
| ±0.078125 V                                  | ±0.0384                   | 10 µV        | ±0.0009                | 40 µV             | ±0.0006                                     | 1                                      |

| Input Bandwidth |                      |
|-----------------|----------------------|
| A/D Data Rate   | -3 db Bandwidth (Hz) |
| 3750 S/s        | 1615                 |
| 2000 S/s        | 878                  |
| 1000 S/s        | 441                  |
| 500 S/s         | 221                  |
| 100 S/s         | 44.2                 |
| 60 S/s          | 26.5                 |
| 50 S/s          | 22.1                 |
| 25 S/s          | 11.1                 |
| 10 S/s          | 4.42                 |
| 5 S/s           | 2.21                 |
| 2.5 S/s         | 1.1                  |

### Noise Performance

Refer to the *USB-2408 Series User's Guide* for noise performance specifications

### Channel Switching Error

Refer to the *USB-2408 Series User's Guide* for channel switching error specifications

### Throughput Rate

The maximum throughput of a USB-2408 Series device is 1.1 kS/s aggregate. The USB-2408 provides the ability to set conversion rates on a per-channel basis. This feature gives the user flexibility and control over noise averaging on a for each channel.

Refer to the *USB-2408 Series User's Guide* for tables and formulas that explain the many options for single- and multichannel throughputs.

### Analog Voltage Output (USB-2408-2AO only)

Unused AOUTx output channels should be left disconnected.

The USB-2408-2AO output voltage level defaults to 0 V whenever the host PC is reset, shut down or suspended, or if a reset command is issued to the device. The duration of the output transient depends highly on the enumeration process of the host computer. Typically, the output of the USB-2408-2AO is stable after two seconds.

**Digital to Analog Converter:** DAC8552

**Number of Channels:** 2

**Resolution:** 16 bits

**Output Ranges**

**Calibrated:** ±10 V

**Uncalibrated:** ±10.05 V, software-selectable

### Output Transient

Host computer is reset, powered on, suspended or a reset command is issued to device

**Duration:** 2 s

**Amplitude:** 2 V p-p

**Initial Power On**

**Duration:** 50 ms

**Amplitude:** 5 V peak

**Differential Non Linearity:** ±0.25 LSB typ, ±1 LSB max

**Output Current:** AOUTx pins, ±5.0 mA max

**Output Short-Circuit Protection**

AOUTx connected to AGND: Unlimited duration

**Output Coupling:** DC

**Power on and Reset State:** DACs cleared to zero-scale, 0 V, ±50 mV

**Output Noise:** 60 µVrms (BW=1.5 KHz)

**Settling Time:** To rated accuracy, 10 V step, 75 µs

**Slew Rate:** 1.0 V/µs

**Throughput**

**Single-Channel:** 1000 S/s max, system-dependent

**Multi-Channel:** 1000 S/s /#ch max, system-dependent

**Calibrated Absolute Accuracy**

**Range:** ±10 V

**Accuracy (±LSB):** 16.0

**Calibrated Absolute Accuracy Components**

**Range:** ±10 V

**% of Reading:** ±0.0183

**Offset:** ±1.831 mV

**Temp Drift (%/°C):** 0.00055

**Absolute Accuracy at FS:** ±3.661 mV

**Relative Accuracy**

**Range:** ±10 V

**Relative Accuracy:** ±4.0 LSB typ

### Analog Input/Output Calibration

**Warm-Up Time:** 45 minutes min

**Calibration:** Firmware calibration

**Calibration Interval:** 1 year

**AI Calibration Reference:** 10.000 V, ±5 mV max

Actual measured values stored in EEPROM

**Tempco:** 5 ppm/°C max

**Long Term Stability:** 30 ppm/1000 hours

**AO Calibration Procedure (USB-2408-2AO Only):** The analog output pin is internally routed to the analog input pin.

**AOUTx Readback (USB-2408-2AO Only, Software-Selectable):** Each AOUTx output can be independently measured by the onboard A/D converter

# USB-2408 Series

## Specifications & Ordering Information



### Digital Input/Output

#### Digital Input

**Number of I/O:** 8 channels

**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOU). DIN bits can be read at any time whether the DOU is active or tri-stated.

**Input Voltage Range:** 0 to 15 V

**Input Type:** CMOS (Schmitt trigger)

**Input Characteristics:** 47 k $\Omega$  pull-up/pull-down resistor, 28 k $\Omega$  series resistor

**Maximum Input Voltage Range:** 0 V to 20 V max (power on/off, relative to DGND)

**Pull-Up/Pull-Down Configuration:** All pins pulled up to 5 V through individual 47 k $\Omega$  resistors (the J6 shorting block default position is pins 1 and 2)

Pull-down capability is available by placing the J6 shorting block across pins 2 and 3

**Transfer Rate (Software Paced):** 500 port reads or single bit reads per second typ

**Input High Voltage:** 1.3 V to 2.2 V

**Input Low Voltage:** 1.5 V to 0.6 V

**Schmitt Trigger Hysteresis:** 0.4 V to 1.2

#### Digital Output

**Number of I/O:** 8 channels

**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOU). DIN bits can be read at any time whether the DOU is active or tri-stated.

**Output Characteristics:** 47 k $\Omega$  pull-up, open drain (DMOS transistor)

Each DMOS transistor source pin is internally connected to DGND

**Pull-Up Configuration:** All pins pulled up to 5 V through individual 47 k $\Omega$  resistors (the J6 shorting block default position is pins 1 and 2).

**Transfer Rate (Software Paced)**

**Digital Output:** 500 port writes or single bit writes per second typ

**Output Voltage Range:** 0 V to 5 V (no external pull up resistor, internal 47 k $\Omega$  pull-up resistors connected to 5 V by default); 0 V to 15 V max

**Drain to Source Breakdown Voltage:** 50 V min

**Off State Leakage Current:** 1.0  $\mu$ A

**Sink Current Capability:** 150 mA max (continuous) per output pin

150 mA max (continuous) for all eight channels

**DMOS Transistor On-Resistance (Drain to Source):** 4  $\Omega$

### Counter

**Pin Names:** CTR0, CTR1

**Number of Channels:** 2 channels

**Resolution:** 32-bits

**Counter Type:** Event counter

**Input Type:** Schmitt trigger, rising edge triggered

**Input Source:** CTR0 (pin 44), CTR1 (pin 42)

**Counter Read/Writes Rates (Software Paced)**

**Counter Read:** System-dependent, 500 reads per second.

**Counter Write:** System-dependent, 500 writes per second.

**Input Characteristics:** Each CTRx input pin has 562 k $\Omega$  resistor pulled up to 5 V and a 10 k $\Omega$  series resistor

**Input Voltage Range:**  $\pm 15$  V max

**Maximum Input Voltage Range:** CTR0,CTR1 relative to GND and DGND,  $\pm 20$  V max (power on/off)

**Input High Voltage:** 1.3 V to 2.2 V

**Input Low Voltage:** 1.5 V to 0.6 V

**Schmitt Trigger Hysteresis:** 0.4 V to 1.2

**Input Bandwidth (-3 dB):** 1 MHz

**Input Capacitance:** 25 pf

**Input Leakage Current:**  $\pm 120$  nA @5 V,  $\pm 1.6$  mA @ $\pm 15$  V

**Input Frequency:** 1 MHz, max

**High Pulse Width:** 500 ns, min

**Low Pulse Width:** 500 ns, min

### Memory

**EEPROM:** 4096 bytes isolated micro reserved for sensor configuration, 256 bytes USB micro for external application use

### Microcontroller

**Type:** One high-performance 8-bit RISC microcontroller with USB interface (non-isolated)

One high-performance 16-bit RISC microcontroller for measurements (isolated)

### Power

**Supply Current:** Quiescent current, 275 mA

This is the total quiescent current requirement for the USB-2408 Series which includes up to 10 mA for the status LED. This does not include any potential loading of the digital I/O bits, +5 V user terminal or the AOUTx outputs.

**Voltage Supervisor Limits:** 4.5 V >  $V_{ext}$  or  $V_{ext}$  > 5.5 V, PWR LED = Off, (power fault)

4.5 V <  $V_{ext}$  < 5.5 V, PWR LED = On

**5 V User Output Voltage Range:** Available at terminal block pin 40, 4.75 V to 5.25 V

**+5 V User Output Current:** Available at terminal block pin 40, 10 mA max

**Isolation:** Measurement system to computer, 500 VDC min

### USB Specifications

**USB Device Type:** USB 2.0 (full-speed)

**Device Compatibility:** USB 1.1, USB 2.0

**USB Cable Type:** A-B cable, UL type AWM 2527 or equivalent (min 24 AWG VBUS/GND, min 28 AWG D+/D-)

**USB Cable Length:** 3 meters max

### Environmental

**Operating Temperature Range:** 0  $^{\circ}$ C to 50  $^{\circ}$ C

**Storage Temperature Range:** -40  $^{\circ}$ C to 85  $^{\circ}$ C

**Humidity:** 0% to 90% non-condensing

### Mechanical

**Dimensions (L  $\times$  W  $\times$  H):** 127  $\times$  89.9  $\times$  35.6 mm (5.00  $\times$  3.53  $\times$  1.40 in.)

**User Connection Length:** 3 meters max

### Screw Terminal Connector

**Connector Type:** Fixed screw terminal

**Wire Gauge Range:** 16 AWG to 30 AWG

## Ordering Information

| Description  | Part No.     |
|--|--------------|
| USB-based 24-bit, isolated, multifunction DAQ device with USB cable                        | USB-2408     |
| USB-based 24-bit, isolated, multifunction DAQ device with two analog outputs and USB cable | USB-2408-2AO |

### Accessories

|  |             |
|--|-------------|
| E-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 1 m | 745690-E001 |
| E-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 2 m | 745690-E002 |
| J-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 1 m | 745690-J001 |
| J-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 2 m | 745690-J002 |
| K-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 1 m | 745690-K001 |
| K-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 2 m | 745690-K002 |
| T-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 1 m | 745690-T001 |
| T-type thermocouples wire, fiberglass (0 $^{\circ}$ C to 482 $^{\circ}$ C, 32 $^{\circ}$ F to 900 $^{\circ}$ F), 2 m | 745690-T002 |

### Software

Icon-based data acquisition, graphics, control, and analysis software DASYLab  
Out-of-the-box virtual instrument suite  
with strip chart, oscilloscope, function generator, and rate generator – professional version TracerDAQ Pro