# USB-2416 Series
## 24-Bit Multifunction Temperature & Voltage Devices

## Features
- Measure thermocouples or voltage
- 32 analog inputs expandable to 64
- 24-bit resolution
- 1 kS/s sampling
- 8 digital I/O
- Two counters
- Up to 4 analog outputs

## 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
- Comprehensive drivers for DASYLab® and NI LabVIEW™
- Linux support through third-party drivers
- InstaCal software utility for installing, calibrating, and testing



*Measurement Computing's USB-2416 Series offers high-resolution voltage or thermocouple measurements along with digital I/O and analog output functionality*

## Overview
The USB-2416 Series are multifunction DAQ devices designed for highly-accurate voltage or temperature measurements. Each device features 32 single-ended (SE)/16 differential (DIFF) analog inputs, expandable to 64 SE/32 DIFF inputs. Analog inputs are user-configurable for voltage or thermocouple input on a per-channel basis. Also included with each device are 8 digital I/O, expandable to 24 channels and two counter inputs. The USB-2416-4AO also features four analog outputs. Each device in the series offers 24-bit resolution for ultra-accurate voltage or thermocouple measurements.

## Analog Input
Each device includes 32 SE/ 16 DIFF analog inputs, expandable to 64 SE/32 DIFF inputs. Nine software-selectable voltage input ranges are provided. These are configurable on a per-channel basis from ±20 V to ±0.078 V. When measuring thermocouples, analog inputs must be configured in DIFF mode. All devices also include open thermocouple detection to identify improperly working thermocouples.

| USB-2416 Series | | | |
|---|---|---|---|
| Model | Analog Inputs | Digital I/O | Analog Outputs |
| USB-2416 | 32 SE/16 DIFF | 8 | — |
| USB-2416-4AO | 32 SE/16 DIFF | 8 | 4 |
| USB-2416 with AI-EXP32 | 64 SE/32 DIFF | 24 | — |
| USB-2416-4AO with AI-EXP32 | 64 SE/32 DIFF | 24 | 4 |

## Sample Rate
The USB-2416 Series can sample analog input channels at up to a 1 kS/s rate.

## Digital I/O
Eight digital I/O channels are included with each USB-2416 Series device, and you can read from or write to each individual bit. The AI-EXP32 expansion device adds 16 additional digital I/O to the system.

## Counters
Two 32-bit counters are included with USB-2416 Series devices. The TTL level inputs are capable of read/write rates of up to 500 Hz with an input frequency of up to 1 MHz.

## Analog Output
Four 16-bit analog outputs are included with the USB-2416-4AO. Each output has a ±10 V range.

## Channel Expansion
The AI-EXP32 is an expansion device can double the analog input count of either the USB-2416 or USB-2416-4AO. It provides up to 32 SE/16 DIFF analog inputs with a 1 kS/s aggregate throughput. Each channel can be individually configured for SE or DIFF input. They offer nine software-selectable analog input ranges (±20 V, ±10 V, ±5 V, ±2.5 V, ±1.25 V, ±0.625 V, ±0.312 V, ±0.156 V, ±0.078 V).

The analog inputs can be configured as thermocouple inputs (up to 16 DIFF). In thermocouple mode, the AI-EXP32 includes built-in cold-junction compensation and open thermocouple detection. The AI-EXP32 also provides up to 16 additional digital I/O lines.

Four banks of removable screw-terminal blocks provide connectivity to the analog input channels and digital I/O lines.

# USB-2416 Series
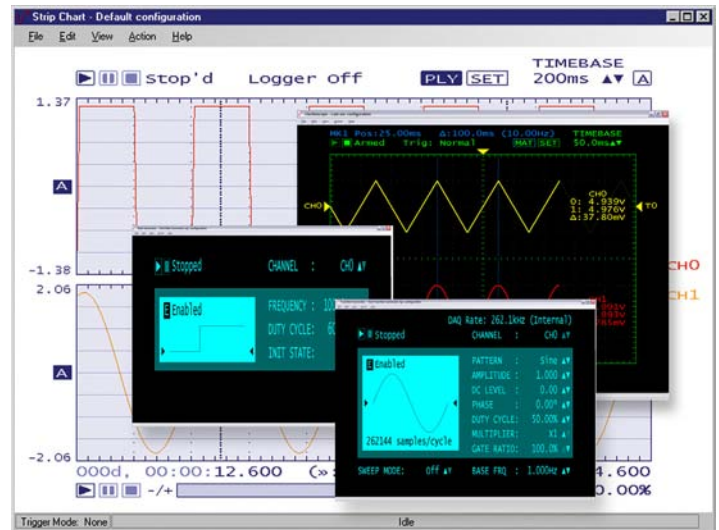## General Information & Specifications

The AI-EXP32 is connected to the USB-2416 Series device with the 37-pin expansion connector. The AI-EXP32 supports all of the analog/thermocouple input and digital I/O features of the USB-2416 Series devices to which it is connected. Power for the AI-EXP32 comes from the USB-2416 series devices.



*The AI-EXP32 connects to a USB-2416 Series device with included hardware*



*TracerDAQ provides four virtual instrument applications used to graphically display and store input data*

## Software

Included with the USB-2416 Series is TracerDAQ, an out-of-the-box application that allows data to be generated, acquired, analyzed, displayed and exported within seconds of installing a Measurement Computing data acquisition device. TracerDAQ includes a strip chart, oscilloscope, function generator, and rate generator, all of which are accessed through a common, easy-to-use menu page.

Also included with the USB-2416 Series is a complete set of drivers and detailed example programs for the most popular programming languages and software packages. Driver support includes Universal Library programming libraries for Windows® Visual Studio® programming languages, and other languages, DASYLab® support, and ULx for NI LabVIEW®. Drivers are also available for Linux.

## 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 samples per second (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**
    **Single Channel:** 2.5 Hz to 1102.94 Hz, software selectable
    **Multiple Channels:** 0.16 Hz to 1102.94 Hz, software selectable
**Number of Channels:** Up to 32 channels individually software configurable as single-ended or differential; thermocouples require differential mode; for each channel configured as differential, you lose one single-ended channel; you can add channels by connecting to an AI-EXP32
**Input Isolation:** 500 VDC min between field wiring and USB interface
**Channel Configurations:** Temperature sensor input, software programmable to match sensor type; voltage input
**Input Voltage Range**
    **Thermocouple Mode:** ±0.078125 V
    **Voltage Mode:** ±20 V, ±10 V, ±5 V, ±2.5 V, ±1.25 V, ±0.625 V, ±0.3125 V, ±0.15625 V, ±0.078125 V, software configurable
**Absolute Maximum Input Voltage:** CxH-CxL relative to GND, ±30 V max (power on), ±10 V max (power off)
**Input Impedance:** 2 GΩ (power on), 390 Ω (power off)
**Input Leakage Current:** ±10.6 nA
**Input Capacitance:** 590 pf

**Maximum Working Voltage (Signal + Common Mode)**
    **Voltage Mode:** ±20 V range, ±20.01 V max; all other voltage input ranges, ±10.25 V max
**Common Mode Rejection Ratio**
    **Thermocouple Mode (fIN = 60 Hz):** 110 dB
    **Voltage Mode (fIN = 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 configurable channel and range
**Warm-Up Time:** 45 minutes min
**Open Thermocouple Detect:** Automatically enabled when the channel is configured for a thermocouple sensor
**CJC Sensor Accuracy:** 15 °C to 35 °C, ±0.15 °C typical; 0 °C to 55 °C, ±0.5 °C max

### Channel Configurations

**CxH/CxL:** Thermocouple, 16 differential channels
**CxH/CxL:** Voltage, 32 individually configurable channels that can be configured as either single ended or differential
**CxH/CxL:** Voltage, 32 individually configurable channels that can be configured as either single ended or differential

### Compatible Sensors

**Thermocouple**
    **J:** –210 °C to 1200 °C
    **K:** –270 °C to 1372 °C
    **R:** –50 °C to 1768 °C
    **S:** –50 °C to 1768 °C
    **T:** –270 °C to 400 °C
    **N:** –270 °C to 1300 °C
    **E:** –270 °C to 1000 °C
    **B:** 0 °C to 1820 °C

## Accuracy

**See User's Guide for thermocouple and voltage measurement accuracy.**

## Throughput Rate

The maximum throughput of USB-2416 Series devices is 1.1 kS/s aggregate. The USB-2416 Series 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 per-channel basis.

**See User's Guide for tables and formulas that describe the many options for single- and multi-channel throughputs.**

## Analog Voltage Output (USB-2416-4AO only)

Unused VDACx output channels should be left disconnected.

The USB-2416-4AO 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 PC. Typically, the output of the USB-2416-4AO is stable after two seconds.

**Digital to Analog Converter:** DAC8555
**Number of Channels:** 4
**Resolution:** 16 bits
**Output Ranges**
   **Calibrated:** ±10 V
   **Uncalibrated:** ±10.05 V, software configurable
**Output Transient**
   Host PC 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 typical, ±1 LSB max
**Output Current:** VDACx pins, ±3.5 mA max
**Output Short-Circuit Protection:** VDACx connected to AGND, unlimited duration
**Output Coupling:** DC
**VDACx Readback:** Each VDACx output can be independently measured by the onboard A/D converter, software selectable
**Power on and Reset State:** DACs cleared to zero-scale, 0 V, ±50 mV
**Output Noise:** 30 μVrms
**Settling Time:** To rated accuracy, 10 V step, 45 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 (±mV):** 1.831
   **Temp Drift (%/°C):** 0.00055
   **Absolute Accuracy at FS (±mV):** 3.661
**Relative Accuracy**
   **Range:** ±10 V
   **Relative Accuracy (±LSB):** 4.0 typical

## Analog Input/Output Calibration

**Warm-Up Time:** 45 minutes min
**Calibration:** Firmware calibration
**Calibration Interval:** 1 year
**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

## Digital Input/Output

### Digital Input

**Number of I/O:** 8 channels
**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOUT); the DIN bits can be read at any time whether the DOUT is active or tri-stated
**Input Voltage Range:** 0 V to 15 V
**Input Type:** CMOS (Schmitt trigger)
**Input Characteristics:** 47 kΩ pull-up/pull-down resistor, 28 kΩ series resistor
**Maximum Input Voltage Range:** 0 V to 20 V max (power on/off, relative to DGND pins 93 and 94)
**Pull-Up/Pull-Down Configuration:** All pins pulled up to +5 V via individual 47 kΩ resistors (the JP1 shorting block default position is pins 1 and 2); pull-down capability is available by placing the JP1 shorting block across pins 2 and 3
**Transfer Rate (Software Paced):** 500 port reads or single bit reads per second typical.
**Input High Voltage:** 1.3 V min, 2.2 V max
**Input Low Voltage:** 1.5 V max, 0.6 V min
**Schmitt Trigger Hysteresis:** 0.4 V min, 1.2 V max

### Digital Output

**Number of I/O:** 8 channels
**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOUT); the DIN bits may be read at any time whether the DOUT is active or tri-stated
**Output Characteristics:** 47 kΩ pull-up, open drain (DMOS transistor)
**Pull-Up Configuration:** All pins pulled up to +5 V via individual 47 kΩ resistors (the JP1 shorting block default position is pins 1 and 2).
**Transfer Rate (Software Paced)**
   **Digital Output:** 500 port writes or single bit writes per second typical.
**Output Voltage Range:** 0 V to 5 V (no external pull up resistor, internal 47 kΩ 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:** 0.1 μA
**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 Ω

## Counter

### CTR Specifications

**Pin Name:** 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 43), CTR1 (pin 45)
**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, 562 kΩ pull-up resistor to +5 V, 10 kΩ series resistor
**Input Voltage Range:** ±15 V max
**Maximum Input Voltage Range:** CTR0,CTR1 relative to GND and DGND, ±20 V max (power on/off)
**Input High Voltage:** 1.3 V min, 2.2 V max
**Input Low Voltage:** 1.5 V max, 0.6 V min
**Schmitt Trigger Hysteresis:** 0.4 V min, 1.2 V max
**Input Bandwidth (–3 dB):** 1 MHz
**Input Capacitance:** 25 pf
**Input Leakage Current:** ±120 nA
**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

# USB-2416 Series
## Specifications & Ordering Information

## 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

The USB-2416 and USB-2416-4AO include an AC power adapter (PS-5V2AEPS)
**Supply Current:** Quiescent current, 340 mA
**External Power Input:** +5 V, ±5%
**External Power Supply:** MCC p/n PS-5V2AEPS (included), +5 VDC, 10 W, 5% regulation
**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 35, 4.9 V min to 5.1 V max
**User +5V User Output Current:** Available at terminal block pin 35, 10 mA max
**Isolation:** Measurement system to PC, 500 VDC min

## AC Power

**Output Voltage:** 5 V, ±5%
**Output Wattage:** 10 watts
**Power Jack Configuration:** Two conductor
**Power Jack Barrel Diameter:** 6.3 mm
**Power Jack Pin Diameter:** 2.0 mm
**Power Jack Polarity:** Center positive

## 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:** 5 meters max

## Environmental

The environmental specifications apply to the USB-2416 and USB-2416-4AO and not to the AC power adapter.
**Operating Temperature Range:** 0 °C to 50 °C max
**Storage Temperature Range:** –40 to 85 °C max
**Humidity:** 0 to 90% non-condensing max

## Mechanical

**Dimensions (L × W × H):** 245 × 146 × 50 mm (9.65 × 5.75 × 1.97 in.)
**User Connection Length:** 5 meters max

## Screw Terminal Connector

**Connector Type:** Detachable screw terminal
**Wire Gauge Range:** 16 AWG to 30 AWG

## Optional AI-EXP32 Expansion Module

Use the AI-EXP32 (sold separately) for applications that need additional analog/thermocouple input and digital I/O channels. See Measurement Computing web site for product details.

The AI-EXP32 expansion port is intended to interface with a USB-2416 series product. Do not try to use any of the expansion port pins for any other purpose.

## Ordering Information

| Description | Part No. |
|---|---|
| USB-based 24-bit, isolated, high-channel-count, multifunction DAQ device | USB-2416 |
| USB-based 24-bit, isolated, high-channel-count, multifunction DAQ device with 4 analog outputs | USB-2416-4AO |

### Signal Conditioning Options

| | |
|---|---|
| Analog input expansion device for USB-2416 Series | AI-EXP32 |

### Accessories

| | |
|---|---|
| DIN-rail kit | ACC-202 |
| DST kit with 6 detachable screw terminals | ACC-216 |
| Replacement power supply for USB-2416 and USB-2416-4AO | PS-5V2AEPS |
| E-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 1 m | 745690-E001 |
| E-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 2 m | 745690-E002 |
| J-type thermocouples wire, fiberglas (0 °C to 482 °C , 32 °F to 900 °F), 1 m | 745690-J001 |
| J-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 2 m | 745690-J002 |
| K-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 1 m | 745690-K001 |
| K-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 2 m | 745690-K002 |
| T-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 1 m | 745690-T001 |
| T-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °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 |