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

The USB-2416 Series offers high-resolution voltage or thermocouple measurements along with digital I/O. Analog output functionality is available with the USB-2416-4AO.

Overview
The USB-2416 Series offers exceptional performance and accuracy for voltage and temperature measurements.

Designed for the USB bus, each device provides up to 32 analog input channels with 24-bit resolution, 8 digital I/O and two counter inputs. The USB-2416-4AO also features four analog outputs.

Connect to the AI-EXP32 expansion device for an additional 32 channels of analog input and 16 digital I/O lines.

Analog inputs are user-configurable for voltage or thermocouple input on a per-channel basis.

Analog Input
Each device provides 32 SE/16 DIFF analog inputs, expandable to 64 SE/32 DIFF. Software-selectable voltage input ranges are configurable per-channel.

USB-2416 Series devices can sample analog input channels at up to 1 kS/s. Open thermocouple detection is automatically enabled for thermocouple measurements.

Analog Output (USB-2416-4AO Only)
The USB-2416-4AO provides four 16-bit analog outputs with a ±10 V output range. The analog outputs can be updated at a maximum rate of 1 kS/s (system-dependent).

Features
- Measure thermocouples or voltage
- 32 analog inputs, expandable to 64
- 24-bit resolution
- 1 kS/s sampling
- 4 analog outputs (USB-2416-4AO only)
- 8 digital I/O, expandable to 24
- Two counters
- Regulated power supply included

Supported Operating Systems
- Windows® 10/8/7/Vista® XP
  32/64-bit

Digital I/O
USB-2416 Series devices provide eight digital I/O lines with read/write rates of 500 port or single bit reads per second. Each DIO channel is an open-drain. Digital outputs can sink up to 150 mA for direct drive applications. The maximum sink current is 150 mA per eight-channel bank, or if all eight channels are used, 18 mA (maximum) per channel.

Counter Input
Each device has two 32-bit event counters that accept frequency inputs up to 1 MHz. The internal counter increments when the TTL levels transition from low to high.

Channel Expansion with the AI-EXP32
The AI-EXP32 expansion device provides an additional 32 SE/16 DIFF analog inputs and 16 DIO lines. The AI-EXP32 supports all analog/thermocouple input and digital I/O features of the USB-2416 Series devices to which it is connected.

USB-2416 Series Selection Chart

<table>
<thead>
<tr>
<th>Model</th>
<th>Analog Inputs</th>
<th>Throughput Rate</th>
<th>Analog Outputs</th>
<th>Digital I/O</th>
<th>Counters</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB-2416</td>
<td>32 SE/16 DIFF</td>
<td>Up to 1 kS/s</td>
<td>—</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>USB-2416-4AO</td>
<td>32 SE/16 DIFF</td>
<td>Up to 1 kS/s</td>
<td>4</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>USB-2416 with AI-EXP32</td>
<td>64 SE/32 DIFF</td>
<td>Up to 1 kS/s</td>
<td>—</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>USB-2416-4AO with AI-EXP32</td>
<td>64 SE/32 DIFF</td>
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<td>24</td>
<td>2</td>
</tr>
</tbody>
</table>

The USB-2416 Series docks directly to the AI-EXP32 with an expansion connector on each device (see page 5). No additional cable is required. Refer to the hardware user’s guide for detailed information.

The AI-EXP32 receives power from the connected USB-2416 Series device.
USB-2416 Series

Features

Calibration
The USB-2416 Series is factory-calibrated using a NIST-traceable calibration process. Specifications are guaranteed for one year. The USB-2416 Series also supports field calibration for users to calibrate the device locally with the InstaCal utility.

Power
The USB-2416 Series receives power from the PS-5V2AEPS external supply that ships with the device.
## USB-2416 Series

### Software Support

USB-2416 Series devices are supported by the software in the table below.

<table>
<thead>
<tr>
<th>Ready-to-Run Applications</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAQami™</td>
<td>Data acquisition companion software with drag-and-drop interface that is used to acquire, view, and log data, and generate signals. DAQami can be configured to log analog, digital, and counter channels, and to view that data in real-time or post-acquisition on user-configurable displays. Logged data can be exported for use in Excel® or MATLAB®. Windows OS DAQami is included with the free MCC DAQ Software bundle. Install DAQami and try the fully-functional software for 30 days. After 30 days, all features except for data logging and data export will continue to be available – data logging and data export features can be unlocked by purchasing the software.</td>
</tr>
<tr>
<td>InstaCal™</td>
<td>An interactive installation, configuration, and test utility for MCC hardware. Windows OS InstaCal is included with the free MCC DAQ Software bundle.</td>
</tr>
<tr>
<td>TracerDAQ™ and TracerDAQ Pro</td>
<td>Virtual strip chart, oscilloscope, function generator, and rate generator applications used to generate, acquire, analyze, display, and export data. Supported features may vary by hardware. The Pro version provides enhanced features. Windows OS TracerDAQ is included with the free MCC DAQ Software bundle. TracerDAQ Pro is available as a purchased software download.</td>
</tr>
</tbody>
</table>

### General-Purpose Programming Support

<table>
<thead>
<tr>
<th>Universal Library™ (UL) for Windows</th>
<th>Library for developing applications in C, C++, VB, C# .Net, VB .Net, and Python on Windows. The UL for Windows is included with the free MCC DAQ Software bundle. The UL Python API for Windows is available on GitHub (<a href="https://github.com/mccdaq/mcculw">github.com/mccdaq/mcculw</a>).</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL for Linux®</td>
<td>Library for developing applications in C, C++, and Python on Linux. UL for Linux is available on GitHub (<a href="https://github.com/mccdaq/uldag">github.com/mccdaq/uldag</a>). Open-source, third-party Linux drivers are also available for supported MCC devices.</td>
</tr>
</tbody>
</table>

### Application-Specific Programming Support

<table>
<thead>
<tr>
<th>ULx for NI LabVIEW™</th>
<th>A comprehensive library of VIs and example programs for NI LabVIEW that is used to develop custom applications that interact with most MCC devices. Windows OS ULx for NI LabVIEW is included with the free MCC DAQ Software bundle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASYLab®</td>
<td>Icon-based data acquisition, graphics, control, and analysis software that allows users to create complex applications in minimal time without text-based programming. Windows OS DASYLab is available as a purchased software download. An evaluation version is available for 28 days.</td>
</tr>
</tbody>
</table>
USB-2416 Series

Specifications

All specifications are subject to change without notice. Typical for 25 °C 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 individually software configurable as single-ended or differential; thermocouples require differential mode
- 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): ±20.01 V max
- Voltage mode (all other voltage ranges): ±10.25 V max

Common mode rejection ratio:
- Thermocouple mode (fns = 60 Hz): 110 dB
- Voltage mode (fns = 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:
- Enabled when configured for a thermocouple sensor

CJC sensor accuracy:
- 15 °C to 35 °C, ±0.15 °C typ; 0 °C to 55 °C, ±0.5 °C max

Analog Voltage Output (USB-2416-4AO only)
Leave unused VDACx channels disconnected. The output voltage defaults to 0 V when the host PC is reset, shut down or suspended. The duration of the output transient depends 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, 16-bit

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:
- ±25 LSB, typ, ±1 LSB max

Output current:
- VDACx pins, ±3.5 mA max

Output short-circuit protection:
- 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 35 °C (±mV): 3.661

Relative accuracy:
- Range: ±10 V
- Relative accuracy (±LSB): 4.0 typical

Digital Input

Number of I/O: 8 channels

Configuration:
- Independently read from (DIN) or written to (DOUT)

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)

Pull-up/pull-down configuration:
- All pins pulled up to +5 V via individual 47 kΩ resistors; pull-up is available with an onboard jumper.

Transferrate (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:
- Independently read from (DIN) or written to (DOUT)

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.

Transfer rate (software paced): 500 port writes or single bit writes per second typical.

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

Channel Configurations

<table>
<thead>
<tr>
<th>Channel</th>
<th>Category</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>CxH/CxL</td>
<td>Thermocouple</td>
<td>16 differential</td>
</tr>
<tr>
<td>CxH/CxL</td>
<td>Voltage</td>
<td>Up to 32, individually configurable as either single ended or differential</td>
</tr>
</tbody>
</table>

Compatible Sensors

<table>
<thead>
<tr>
<th>Thermocouple Sensor Types</th>
<th>J</th>
<th>−210 °C to 1200 °C</th>
<th>T</th>
<th>−270 °C to 400 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>−270 °C to 1372 °C</td>
<td>N</td>
<td>−270 °C to 1300 °C</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>−50 °C to 1768 °C</td>
<td>E</td>
<td>−270 °C to 1000 °C</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>−50 °C to 1768 °C</td>
<td>B</td>
<td>0 °C to 1820 °C</td>
<td></td>
</tr>
</tbody>
</table>

Accuracy

Refer to the user's guide for thermocouple and voltage measurement accuracy tables.

Throughput Rate

The maximum throughput is 1.1 kS/s aggregate. Users can set conversion rates on a per-channel basis. Refer to the hardware user's guide for single- and multi-channel throughput rates.
USB-2416 Series

Ordering

Counter Input
Pin name: CTR0, CTR1
Number of channels: 2 channels
Resolution: 32-bits
Counter type: Event counter
Input type: Schmitt trigger, rising edge triggered
Counter read/writes rates: System dependent, 500 reads per second
Input characteristics: Each CTRx input pin, 562 kΩ 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

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

Environmental
Operating Temperature range: 0 °C to 50 °C max
Storage temperature range: –40 to 85 °C max
Humidity: 0 to 90% non-condensing max
These specifications do not apply to the AC power adapter.

Power
Supply current: Quiescent current, 340 mA
Voltage supervisor limits: 4.5 V > V_{\text{ext}} or V_{\text{ext}} > 5.5 V PWR LED = Off, (power fault); 4.5 V < V_{\text{ext}} < 5.5 V, PWR LED = On
+5 V user output voltage range: 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 adapter: MCC p/n PS-5V2AEPS, included with hardware
External power input: +5 VDC, 2.4 A, 12 Watt, 5% regulation

Software also Available from MCC

The USB-2416 Series docked to the AI-EXP32

Ordering Information

Hardware

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>USB-2416</td>
<td>24-bit, isolated, high-channel-count USB DAQ device. Includes USB cable, power adapter, and MCC DAQ software CD.</td>
</tr>
<tr>
<td>USB-2416-4AO</td>
<td>24-bit, isolated, high-channel-count, USB DAQ device with 4 analog outputs. Includes USB cable, power adapter, and MCC DAQ software CD.</td>
</tr>
<tr>
<td>AI-EXP32</td>
<td>Analog input expansion module for USB-2416 Series</td>
</tr>
</tbody>
</table>

Accessories

<table>
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<tr>
<th>Part No.</th>
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</tr>
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<tbody>
<tr>
<td>ACC-202</td>
<td>DIN-rail kit.</td>
</tr>
<tr>
<td>ACC-216</td>
<td>Connector kit with 6 detachable screw terminals.</td>
</tr>
<tr>
<td>PS-5V2AEPS</td>
<td>Replacement power supply, 12-watt. Interchangeable plugs are available separately.</td>
</tr>
<tr>
<td>745690-E001</td>
<td>E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m</td>
</tr>
<tr>
<td>745690-E002</td>
<td>E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
</tr>
<tr>
<td>745690-J001</td>
<td>J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m</td>
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<td>745690-J002</td>
<td>J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
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<td>745690-K001</td>
<td>K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m</td>
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<td>K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
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<tr>
<td>745690-T001</td>
<td>T-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m</td>
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<tr>
<td>745690-T002</td>
<td>T-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
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Software also Available from MCC

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<tr>
<td>DAQami</td>
<td>Data acquisition companion software for acquiring data and generating signals</td>
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<tr>
<td>TracerDAQ Pro</td>
<td>Out-of-the-box virtual instrument suite with strip chart, oscilloscope, function generator, and rate generator – professional version</td>
</tr>
<tr>
<td>DASYLab</td>
<td>Icon-based data acquisition, graphics, control, and analysis software</td>
</tr>
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