USB-2408 Series
24-Bit Multifunction Temperature & Voltage Devices

Overview
The USB-2408 Series are multifunction DAQ devices designed for highly-accurate voltage or temperature measurements. Each device features provides up to 16 single-ended (SE)/8 differential (DIFF) analog inputs, 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 thermocouple 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 ±10 V to ±0.078 V.

When measuring TCs, configure analog inputs in DIFF mode. All devices also include open TC detection to identify improperly working thermocouples.

Sample Rate
USB-2408 Series devices can sample analog input channels at up to a 1 kS/s. Refer to the hardware user’s guide for information about how noise filtering affects the throughput rate for analog inputs.

Analog Output
(USB-2408-2AO only)
The USB-2408-2AO includes two 16-bit analog outputs. Each output has a ±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.

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

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

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.

Counter Input
Two 32-bit event counters are provided to count TTL pulses at read/write rates of up to 500 Hz. The counters accept inputs of up to 1 MHz.

Calibration
The USB-2408 Series is factory-calibrated using a NIST-traceable calibration process. Specifications are guaranteed for one year.

The USB-2408 Series also supports field calibration for users to calibrate the device locally with the InstaCal utility.

USB-2408 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-2408</td>
<td>16 SE/8 DIFF</td>
<td>Up to 1 kS/s</td>
<td>—</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>USB-2408-2AO</td>
<td>16 SE/8 DIFF</td>
<td>Up to 1 kS/s</td>
<td>2</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>
## USB-2408 Series Software

### Software Support

USB-2408 Series devices are supported by the software in the table below.

<table>
<thead>
<tr>
<th>Ready-to-Run Applications</th>
<th>Description</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>

<table>
<thead>
<tr>
<th>General-Purpose Programming Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal Library™ (UL) for Windows</td>
</tr>
<tr>
<td>UL for Linux®</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application-Specific Programming Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULx for NI LabVIEW™</td>
</tr>
<tr>
<td>DASYLab®</td>
</tr>
</tbody>
</table>
USB-2408 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 (S/s): 3750, 2000, 1000, 500, 100, 60, 50, 25, 10, 5, 2.5
A/D resolution: 24 bits

**Throughput**

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 SE/ DIFF

**Input isolation:** 500 VDC min between field wiring and USB interface

**Channel configurations:** Temperature sensor input, voltage input

**Input voltage range**

Thermocouple mode (V): ±0.078125
Voltage mode (V): ±0.1, ±0.25, ±0.5, ±0.625, ±0.125, ±0.15625, ±0.2, ±0.25, ±0.3125, ±0.4, ±0.5

**Absolute maximum input voltage**

CxH/CxL relative to GND: ±22 V max (power on), ±10 V max (power off)
Input impedance: 10 MΩ (power on), 390 Ω (power off)
Input leakage current: ±20 nA (power on); ±50 nA (power off)
Input capacitance: 590 pf

**Working voltage (signal + common mode):** Voltage mode ±0.25 V max

**Common mode rejection ratio**

Thermocouple mode (f = 60 Hz): 110 dB
Voltage mode (f = 60 Hz, all input ranges): 90 dB

**Cross talk:** 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

**CJC sensor accuracy**

15 °C to 35 °C: ±0.5 °C typ
0 °C to 55 °C: ±1.0 °C max

**Channel Configurations**

CxH/CxL: 8 DIFF channels
Voltage: 16 SE or 8 DIFF; individually configurable

**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
B: ~270 °C to 1000 °C
E: 0 °C to 1820 °C
## Thermocouple Measurement Accuracy

<table>
<thead>
<tr>
<th>TC Type</th>
<th>Temp. Range</th>
<th>Accuracy Error, max</th>
<th>Accuracy Error, typ</th>
<th>Tempco (°C/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>−210 °C</td>
<td>±2.572 °C</td>
<td>±1.416 °C</td>
<td>±0.022</td>
</tr>
<tr>
<td></td>
<td>0 °C</td>
<td>±0.935 °C</td>
<td>±0.469 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1200 °C</td>
<td>±1.869 °C</td>
<td>±1.456 °C</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>−210 °C</td>
<td>±2.917 °C</td>
<td>±1.699 °C</td>
<td>±0.029</td>
</tr>
<tr>
<td></td>
<td>0 °C</td>
<td>±1.017 °C</td>
<td>±0.526 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1372 °C</td>
<td>±2.478 °C</td>
<td>±2.022 °C</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>−200 °C</td>
<td>±3.480 °C</td>
<td>±2.030 °C</td>
<td>±0.029</td>
</tr>
<tr>
<td></td>
<td>0 °C</td>
<td>±1.201 °C</td>
<td>±0.659 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1300 °C</td>
<td>±1.991 °C</td>
<td>±1.600 °C</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>−50 °C</td>
<td>±4.826 °C</td>
<td>±3.133 °C</td>
<td>±0.082</td>
</tr>
<tr>
<td></td>
<td>250 °C</td>
<td>±2.117 °C</td>
<td>±1.424 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1678 °C</td>
<td>±2.842 °C</td>
<td>±2.347 °C</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>−50 °C</td>
<td>±4.510 °C</td>
<td>±2.930 °C</td>
<td>±0.089</td>
</tr>
<tr>
<td></td>
<td>250 °C</td>
<td>±2.165 °C</td>
<td>±1.468 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1678 °C</td>
<td>±3.187 °C</td>
<td>±2.597 °C</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>250 °C</td>
<td>±5.489 °C</td>
<td>±3.956 °C</td>
<td>±0.14</td>
</tr>
<tr>
<td></td>
<td>700 °C</td>
<td>±2.283 °C</td>
<td>±1.743 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1820 °C</td>
<td>±2.802 °C</td>
<td>±1.842 °C</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>−200 °C</td>
<td>±2.413 °C</td>
<td>±1.352 °C</td>
<td>±0.017</td>
</tr>
<tr>
<td></td>
<td>0 °C</td>
<td>±1.069 °C</td>
<td>±0.551 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000 °C</td>
<td>±1.575 °C</td>
<td>±1.211 °C</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>−200 °C</td>
<td>±2.821 °C</td>
<td>±1.676 °C</td>
<td>±0.027</td>
</tr>
<tr>
<td></td>
<td>0 °C</td>
<td>±1.050 °C</td>
<td>±0.558 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400 °C</td>
<td>±0.957 °C</td>
<td>±0.595 °C</td>
<td></td>
</tr>
</tbody>
</table>

Includes CJC measurement error and polynomial linearization error; valid for one year or 3000 operating hours. Each terminal block has a CJC sensor. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Connect thermocouples so that they float with respect to AGND.

## Analog Input DC Voltage Measurement Accuracy

<table>
<thead>
<tr>
<th>Range</th>
<th>Gain Error (% of Reading)</th>
<th>Offset Error</th>
<th>INL Error (% of Range)</th>
<th>Absolute Accuracy</th>
<th>Gain Temperature Coefficient (% Reading/°C)</th>
<th>Offset Temperature Coefficient (µV/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10 V</td>
<td>±0.0037</td>
<td>50 µV</td>
<td>±0.0008</td>
<td>500 µV</td>
<td>±0.0006</td>
<td>3</td>
</tr>
<tr>
<td>±5 V</td>
<td>±0.0047</td>
<td>25 µV</td>
<td>±0.0008</td>
<td>300 µV</td>
<td>±0.0006</td>
<td>2</td>
</tr>
<tr>
<td>±2.5 V</td>
<td>±0.0059</td>
<td>20 µV</td>
<td>±0.0008</td>
<td>200 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
<tr>
<td>±1.25 V</td>
<td>±0.0056</td>
<td>20 µV</td>
<td>±0.0008</td>
<td>100 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
<tr>
<td>±0.625 V</td>
<td>±0.0068</td>
<td>15 µV</td>
<td>±0.0005</td>
<td>60 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
<tr>
<td>±0.3125 V</td>
<td>±0.0104</td>
<td>15 µV</td>
<td>±0.0006</td>
<td>50 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
<tr>
<td>±0.15625 V</td>
<td>±0.0184</td>
<td>10 µV</td>
<td>±0.0005</td>
<td>40 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
<tr>
<td>±0.078125 V</td>
<td>±0.0384</td>
<td>10 µV</td>
<td>±0.0009</td>
<td>40 µV</td>
<td>±0.0006</td>
<td>1</td>
</tr>
</tbody>
</table>

Includes CJC measurement error and polynomial linearization error; valid for one year or 3000 operating hours. Each terminal block has a CJC sensor. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Connect thermocouples so that they float with respect to AGND.

## Input Bandwidth

<table>
<thead>
<tr>
<th>A/D Data Rate (S/s)</th>
<th>–3 db Bandwidth (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3750</td>
<td>1615</td>
</tr>
<tr>
<td>2000</td>
<td>878</td>
</tr>
<tr>
<td>1000</td>
<td>441</td>
</tr>
<tr>
<td>500</td>
<td>221</td>
</tr>
<tr>
<td>100</td>
<td>44.2</td>
</tr>
<tr>
<td>60</td>
<td>26.5</td>
</tr>
<tr>
<td>50</td>
<td>22.1</td>
</tr>
<tr>
<td>25</td>
<td>11.1</td>
</tr>
<tr>
<td>10</td>
<td>4.42</td>
</tr>
<tr>
<td>5</td>
<td>2.21</td>
</tr>
<tr>
<td>2.5</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Refer to the USB-2408 or USB-2408-2AO user's guide for the following specifications:
- Noise performance
- Channel switching error

Throughput rate: The maximum throughput is 1.1 kS/s aggregate. The USB-2408 can set conversion rates on a per-channel basis. Refer to the hardware user's guide for tables and formulas for single- and multichannel throughputs.

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

Leave unused AOUTx output channels 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 output of the USB-2408-2AO is typically 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 reset command issued
Duration: 2 s
Amplitude: 2 V p-p
Initial power on
Duration: 50 ms
Amplitude: 5 V peak
Differential nonlinearity: ±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
USB-2408 Series
Specifications

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; 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

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), DIN bits can be read at any time whether the DOUT is active or tri-stated.
Input voltage range: 0 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/down configuration: All pins pulled up to 5 V through individual 47 kΩ resistors. Configure for pull-down with 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 CIO bit can be independently read from (DIN) or written to (DOUT), DIN bits can be read at any time whether the DOUT is active or tri-stated.
Output characteristics: 47 kΩ 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 kΩ 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 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: 1.0 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
Pin names: CTR0, CTR1
Number of channels: 2
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 kΩ resistor pulled up to 5 V and a 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 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: ±120 nA @5 V, ±1.6 mA @±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_{min} or V_{max} > 5.5 V, PWR LED = Off, (power fault)
  - 4.5 V < V_{min} < 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 m (9.84 ft) max

Environmental
Operating temperature range: 0 °C to 50 °C
Storage temperature range: -40 °C to 85 °C
Humidity: 0% to 90% non-condensing

Mechanical
Dimensions (L × W × H): 127 × 89.9 × 35.6 mm (5.00 × 3.53 × 1.40 in.)
User connection length: 3 m (9.84 ft) max

Screw Terminal Connector
Connector type: Fixed screw terminal
Wire gauge range: 16 AWG to 30 AWG

Measurement Computing (508) 946-5100  info@mccdaq.com  mccdaq.com
USB-2408 Series

Ordering

Order Information

Hardware

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB-2408</td>
<td>USB-based 24-bit, isolated, 16 SE/8 DIFF temperature and voltage measurement device with 8 digital I/O, and 2 counter inputs</td>
</tr>
<tr>
<td>USB-2408-2AO</td>
<td>USB-based 24-bit, isolated, 16 SE/8 DIFF temperature and voltage measurement device with 8 digital I/O, 2 counter inputs, and 2 analog outputs</td>
</tr>
</tbody>
</table>

Accessories

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<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>
</tr>
<tr>
<td>745690-J002</td>
<td>J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
</tr>
<tr>
<td>745690-K001</td>
<td>K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m</td>
</tr>
<tr>
<td>745690-K002</td>
<td>K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m</td>
</tr>
<tr>
<td>745690-T001</td>
<td>T-type thermocouples wire, fiberglass (0 °C to 260 °C, 32 °F to 500 °F), 1 m</td>
</tr>
<tr>
<td>745690-T002</td>
<td>T-type thermocouples wire, fiberglass (0 °C to 260 °C, 32 °F to 500 °F), 2 m</td>
</tr>
</tbody>
</table>

Software also Available from MCC

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<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>
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<tr>
<td>DASYLab</td>
<td>Icon-based data acquisition, graphics, control, and analysis software</td>
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Ordering