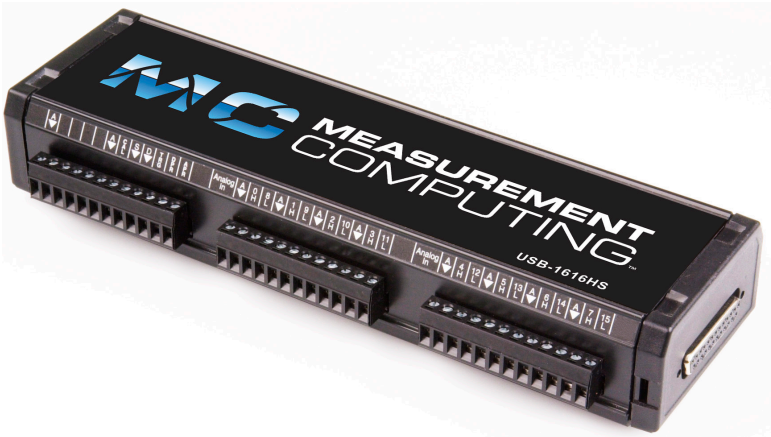
USB-1616HS Series

USB 1 MHz, 16-Bit Multifunction Devices



The USB-1616HS Series provides 1 MS/s sampling, synchronous multifunction I/O, analog input expansion capability, and extensive software support.

Features

- Up to 1 MS/s sample rate
- Synchronous analog, digital, and counter/timer I/O
- 16 SE/8 DIFF 8 analog inputs, software selectable per channel
- Expandable up to 64 SE/32 DIFF
- Up to four analog outputs
- 24 high-speed digital I/O lines
- Four 32-bit counter channels
- Quadrature encoder support
- Low-latency
- TR-2U external supply included

Supported Operating Systems

- Windows® 11/10/8/7/Vista®/ XP 32/64-bit

Overview

The USB-1616HS Series offers high-speed, multifunction data acquisition in a low-cost, portable package. These devices feature synchronous and concurrent voltage input, temperature input, waveform output, counter input, quadrature encoder input, timer output, and digital I/O, ensuring deterministic I/O among all signal types.

Analog Input

The USB-1616HS Series has a 16-bit, 1 MHz A/D coupled with 16 SE, 8 DIFF analog inputs, or 8 DIFF thermocouple inputs. Seven software programmable ranges provide inputs from ±10 V to ±100 mV full scale. Each channel is software configurable for a different range and channel mode. Thermocouples can be connected to each differential input. Built-in cold-junction sensors are provided for each screw terminal connector, and any TC type can be attached to any channel.

Synchronous I/O

The USB-1616HS Series can make analog measurements and read digital and counter inputs, while synchronously generating up to four analog outputs as well as digital pattern outputs.

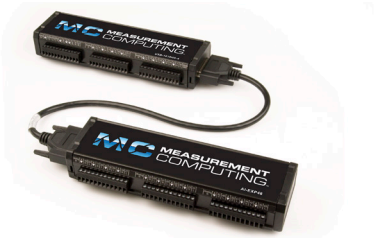
Digital and counter inputs do not affect the overall A/D rate because they use no time slot in the scanning sequencer. An analog input channel can be scanned at the full 1 MHz A/D rate along with digital and counter input channels. The 1 MHz A/D rate is unaffected by the additional digital and counter channels.

Analog Channel Expansion

Adding additional analog input channels is easy using the optional AI-EXP48 expansion device. Users can connect to the AI-EXP48 by plugging directly into the expansion connector or with a cable.

The AI-EXP48 provides an additional 48 SE/24 DIFF analog inputs, or 24 DIFF thermocouple inputs, software configurable per channel, for a total channel capacity of 64 SE or 32 DIFF inputs.

The measurement speed of AI-EXP48 channels is the same 1 MS/s as with USB-1616HS Series channels. When configured to measure thermocouple channels, the system sample rate is typically 50 Hz to 10 kHz per channel. This reduction in sample rate insures that temperature measurements are accurate, exhibit low noise, and are stable.



USB-1616HS-2 attached to a AI-EXP48 expansion device by a CA-96A cable

USB-1616HS-2 attached to a AI-EXP48 expansion device

USB-1616HS Series Selection Chart

Model	Analog Input	Analog Output	DIO	Counter/Timer
USB-1616HS	16 SE/8 DIFF	0	24	4/2
USB-1616HS-2	16 SE/8 DIFF	2	24	4/2
USB-1616HS-4	16 SE/8 DIFF	4	24	4/2
USB-1616HS + AI-EXP48	64 SE/32 DIFF	0	24	4/2
USB-1616HS-2 + AI-EXP48	64 SE/32 DIFF	2	24	4/2
USB-1616HS-4 + AI-EXP48	64 SE/32 DIFF	4	24	4/2

USB-1616HS Series

Features

Input Scanning

The USB-1616HS Series has several scanning modes to address a wide variety of applications. The scan buffer can be loaded with any combination of analog input channels. All channels in the scan buffer are measured sequentially at 1 µs per channel. The sequence can be configured to repeat immediately or after a programmable delay. In the fastest mode (0 delay), a single analog input channel can be scanned continuously at 1 MS/s, two channels at 500 KS/s each, and 16 channels at 62.5 KS/s.

The digital and counter inputs can be read in several modes. With software, the digital inputs or counter inputs can be read asynchronously at anytime before, during, or after an analog input scan sequence.

In either of the two synchronous modes, the digital inputs and/or counter inputs are read with deterministic time correlation to the analog inputs. In the once-per-scan mode, all of the enabled digital inputs and counter inputs are read during the first analog measurement of an analog input scan sequence. The advantage of this mode is that the digital and counter inputs do not consume an analog input time slot, and therefore do not reduce the available bandwidth for analog input measurements.

Output Timing

Digital and analog outputs can be updated asynchronously or synchronously in several modes. In the asynchronous mode, digital and analog outputs can be updated at anytime before, during, or subsequent to an analog input sequence. The maximum update rate in this mode is non-deterministic and entirely dependent on the PC processor speed, the operating system, and programming environment.

In the synchronous output modes, the outputs can be updated continuously from the PC, or as the result of an input from either an analog, digital, or counter channel (refer to "Low-Latency Setpoint Control Mode" below).

When updated from the PC, the user can specify the update rate. Outputs are updated synchronously at a maximum rate of 1 µs. For example, four analog outputs can be generating different waveforms from PC memory, while concurrently generating up to 16 bits of digital pattern. The maximum rate is dependent on a number of factors, including the speed of the USB port. Typically, a total output bandwidth of 6 MS/s can be achieved.

Low-Latency Setpoint Control Mode

Any output channel can be associated with any input channel. The output state/level is determined by the input state/level. For example, a digital output is programmed for logic 1 when an analog input exceeds a certain value, or when a frequency input exceeds a certain rate. Hysteresis can be programmed for each limit to insure the output is stable near the transition point.

Up to 8 digital outputs, 4 analog outputs, and 2 timer outputs can be programmed to respond to any analog, digital, or counter input. When analog or digital outputs are used in this mode, the user can specify two output values, determined by whether the input is above or below the limit.

Analog Output (USB-1616HS-2 and USB-1616HS-4)

The USB-1616HS Series provides four 16-bit, 1 MHz analog output channels with a ±10 V output range. The maximum rate at which analog outputs can be updated is dependent on several factors, including the speed of your USB port. Typically, with the A/D operating at full 1 MS/s rates, all 4 analog outputs can be updated continuously from PC memory at 1 MHz.

A program can asynchronously output a value to any of the D/As for non-waveform applications when the D/A is not being used in waveform output mode. Each analog output can be used in a control mode, where their output level is dependent on whether an associated analog, digital, or counter input is above or below a user-specified limit condition.

When generating waveforms, each output can be clocked asynchronously or asynchronously using an internal or external clock.

Digital I/O

The 24 TTL-level DIO lines are available as three 8-bit ports that can be configured for input or output. Several scanning modes are available (see Input Scanning).

Digital inputs can be synchronously scanned with analog input channels (at the start of the scan or along with the analog channels), or asynchronously accessed through the PC at any time.

- When scanned at the start of each scan sequence, the rate is dependent on the number of analog channels and the delay period. With 8 analog inputs and a 0 delay period, the digital inputs are scanned once per 8 µs ,or 125 kHz.
- When scanned along with analog inputs, the digital inputs would be scanned once per µs, or 1 MHz.
- If no analog inputs are being scanned, the digital inputs can be scanned at up to 12 MS/s.

The low-latency output mode allows the user to associate a digital output bit with a specific input, and specify the level of the input where the digital output changes state. The response time in this mode is dependent on the number of input channels being scanned, and can typically be in the range of 2 to 6 µs.

Pattern Generation

Two of the 8-bit ports can be used to generate a 16-bit digital pattern at up to 1 MHz. The digital pattern can be read from PC RAM, or a file on the hard disk. Digital pattern generation is clocked in the same four modes as described with analog output.

USB-1616HS Series

Features and Block Diagram

Counter Inputs

The four 32-bit counters accept frequency inputs up to 20 MHz, and can be configured in a variety of modes including counter, period, pulse width, time between edges, or multi-axis quadrature encoder. The counters can concurrently monitor time periods, frequencies, pulses, and other event-driven incremental occurrences from encoders, pulse generators, limit switches, proximity switches, and magnetic pick-ups.

The counter inputs can be read asynchronously under program control, or synchronously as part of an analog and digital scan group based either on an internal programmable timer, or an external clock source. The use of Z-channel encoders or usage of mapped channels requires that these channels need to be read synchronously.

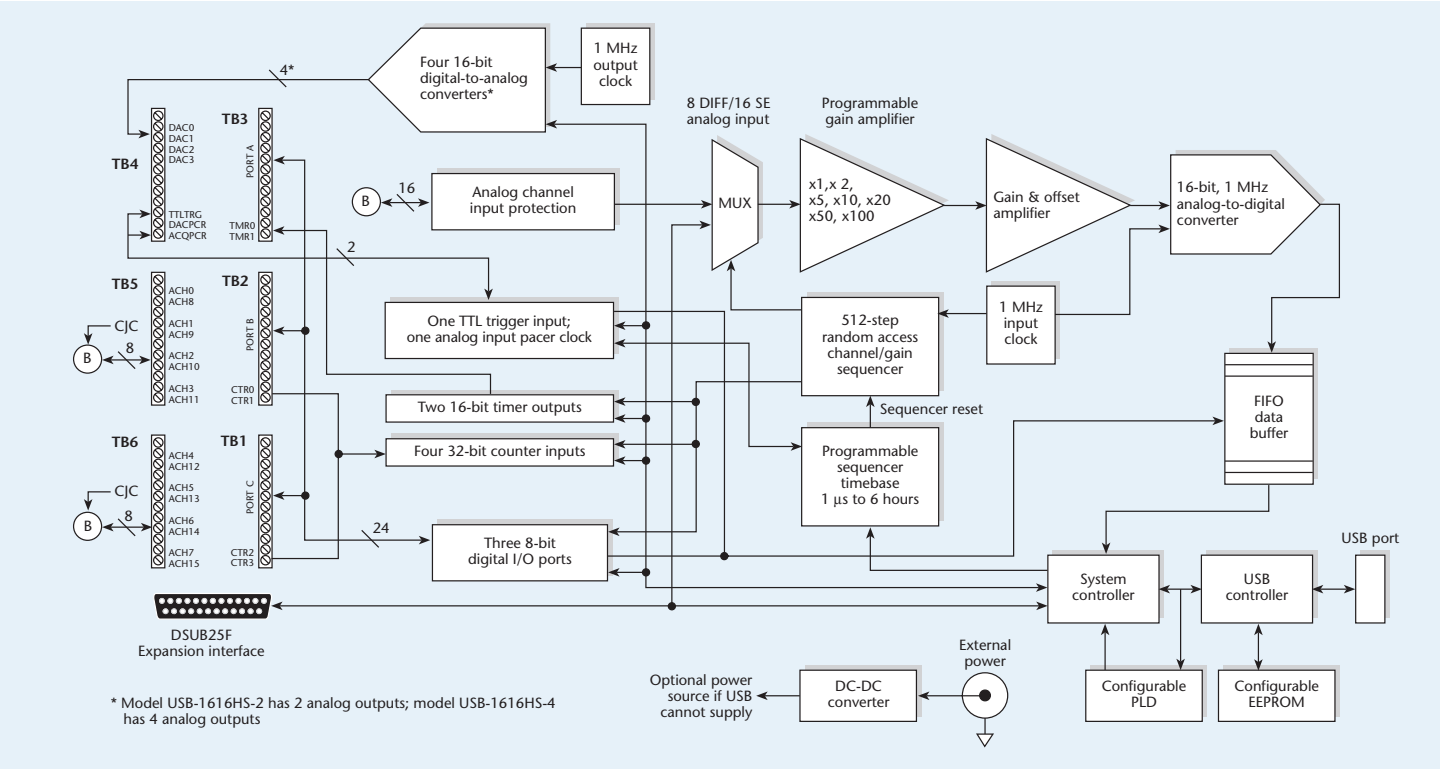
Quadrature encoders

The USB-1616HS Series supports quadrature encoders with up to 2 billion pulses per revolution, 20 MHz input frequencies, and x1, x2, x4 count modes. Two channels are supported using A phase and B phase signals. One channel is supported using A phase, B phase, and Z index signals.

Each input can be debounced to eliminate extraneous noise or switch induced transients. Encoder input signals must be within –5 V to 10 V and the switching threshold is TTL (1.3 V).

Timer Outputs

Two 16-bit timer outputs can generate different square waves with a programmable frequency range from 16 Hz to 1 MHz.

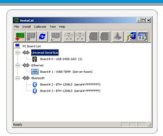
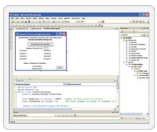
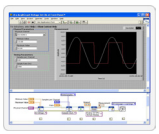


USB-1616HS Series

Software

Software Support

The USB-1616HS Series is supported by the software in the table below.

Ready-to-Run Applications		
InstaCal™		An interactive installation, configuration, and test utility for MCC hardware. Windows OS InstaCal is included with the free MCC DAQ Software bundle (CD/download).
TracerDAQ™ and TracerDAQ Pro		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 (CD/download). TracerDAQ Pro is available as a purchased software download.
General-Purpose Programming Support		
Universal Library™ (UL)		Library for developing applications in C, C++, VB, C# .Net, VB .Net, and Python. Windows OS The UL is included with the free MCC DAQ Software bundle (CD/download).
Application-Specific Programming Support		
ULx for NI LabVIEW™		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 (CD/download).
DASYLab®		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.
MATLAB® driver		High-level language and interactive environment for numerical computation, visualization, and programming. The Mathworks Data Acquisition Toolbox™ allows users to acquire data from most MCC PCI and USB devices. Visit www.MathWorks.com for more information about the Data Acquisition Toolbox.

Specifications

Analog Input

A/D Converter Type: Successive approximation
Resolution: 16 bit
Channels: 16 SE or 8 DIFF, programmable on a per-channel basis as SE or DIFF
Input Ranges: Software or sequencer selectable on a per-channel basis, ±10 V, ±5 V, ±2 V, ±1 V, ±0.5 V, ±0.2 V, ±0.1 V
Maximum Sample Rate: 1 MHz
Nonlinearity (Integral): ±2 LSB max
Nonlinearity (DIFF): ±1 LSB max
A/D pacing: onboard scan clock, external source (APR)
Trigger sources and modes: See Triggering
Acquisition Data Buffer: 1 MS
Data transfer: DMA
Configuration memory: Programmable I/O
Maximum Usable Input Voltage Common Mode Voltage (CMV + V_{IN})
±10 V, ±5 V, ±2 V, ±1 V, ±0.5 V range: 10.5 max
±0.1 V, ±0.2 V range: 2.1 V max
Signal to Noise and Distortion: 72 dB typ for ±10 V range, 1 kHz fundamental
Total Harmonic Distortion: –80 dB typ for ±10 V range, 1 kHz fundamental
Calibration: Auto-calibration, cal factors for each range stored in non-volatile RAM
Common Mode Rejection: –70 dB typ DC to 1 kHz
Bias Current: 40 pA typical (0 ˚C to 35 ˚C)
Crosstalk: –75 dB typ DC to 60 Hz; –65 dB typ @ 10 kHz
Input Impedance: 10 MΩ SE; 20 MΩ DIFF
Absolute Maximum Input Voltage: ±30 V

Accuracy			
Voltage Range[1]	Accuracy[2]	Temperature Coefficient[3]	Noise[4]
–10 V to 10 V	0.031% + 0.008%	14 + 8	2.0
–5 V to 5 V	0.031% + 0.009%	14 + 9	3.0
–2 V to 2 V	0.031% + 0.010%	14 + 10	2.0
–1 V to 1 V	0.031% + 0.02%	14 + 12	3.5
–500 mV to 500 mV	0.031% + 0.04%	14 + 18	5.5
–200 mV to 200 mV	0.036% + 0.075%	14 + 12	8.0
–100 mV to 100 mV	0.042% + 0.15%	14 + 18	14.0

[1] The specification assumes differential input single channel scan, 1 MHz scan rate, unfiltered, CMV=0.0 V, 30-min warm-up, exclusive of noise, range –FS to +FS.
[2] ±(% of reading, + % range); 23 °C ±10 °C, 1 year.
[3] ± (ppm of reading + ppm range)/ °C
[4] cts(RMS). Noise reflects 10,000 samples at 1 MHz, typical, differential short.

TC Types and Accuracy†			
TC Type	Temp. Range (°C)	Accuracy (±°C)	Noise (±°C)
J	–200 to 760	1.7	0.2
K	–200 to 1200	1.8	0.2
T	–200 to 400	1.8	0.2
E	–270 to 650	1.7	0.2
R	–50 to 1768	4.8	1.5
S	–50 to 1768	4.7	1.5
N	–270 to 1300	2.7	0.3
B	300 to 1400	3.0	1.0

† Assumes 16384 oversampling applied, CMV = 0.0 V, 60 minute warm-up, still environment, and 25 ˚C ambient temperature; excludes thermocouple error; TC_{IN} = 0 ˚C for all types except B (1000 ˚C), TR-2U power supply for external power.

Analog Outputs (USB-1616HS-2/USB-1616HS-4 only)

Analog output channels are updated synchronously relative to scanned inputs, and clocked from either an internal clock, or an external clock source. Analog outputs can also be updated asynchronously, independent of any other scanning in the system.
Channels
USB-1616HS-2: 2 DAC channels
USB-1616HS-4: 4 DAC channels
Resolution: 16 bits
Data Buffer: PC-based memory
Output Voltage Range: ±10 V
Output Current: ±1 mA
Offset Error: ±0.0045 V max
Digital Feedthrough: <10 mV when updated
DAC Analog Glitch: <12 mV typical at major carry
Gain Error: ±0.01%
Update Rate: 1 MHz max
Settling Time: 2 µs to rated accuracy
Clock Sources: 4, programmable; internal D/A clock, internal scanning input clock, external D/A input clock, external scanning input clock

Digital I/O

Channels: 24
Ports: 3 x 8-bit, each port is programmable as input or output
Input Scanning Modes: 2 programmable; 1) asynchronous, under program control at any time relative to input scanning, and 2) synchronous with input scanning
Input Characteristics: 220 Ω series resistor, 20 pF to common
Logic Keeper Circuit: Holds the logic value to 0 or 1 when there is no external driver.
Input Protection: ±15 kV ESD clamp diodes
Input Levels
Low: 0 V to 0.8 V
High: 2.0 V to 5.0 V
Output Levels
Low: <0.8 V
High: >2.0 V
Output Characteristics: Output 1.0 mA per pin
Sampling: 4 MHz max
Update Rate: 4 MHz max

Pattern Generation Output

Two of the 8-bit ports can be configured for 16-bit pattern generation. The pattern can also be updated synchronously with an acquisition at up to 4 MHz.

Counter

Each of the four high speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or multi-axis quadrature encoder modes. Counter inputs can be scanned synchronously along with analog and digital scanned inputs, based on an internal programmable timer, or an external clock source.
Channels: 4 x 32-bit
Input Frequency: 20 MHz max
Input Signal Range: –5 V to 10 V
Input Characteristics: 10 kΩ pull-up, 200 Ω series resistor, ±15 kV ESD protection
Trigger Level: TTL
Minimum Pulse Width: 25 ns high, 25 ns low
Debounce Times: 16 selections from 500 ns to 25.5 ms; positive or negative edge sensitive; glitch detect mode or debounce mode
Time Base Accuracy: 50 ppm (0 ˚C to 50 ˚C)
Five Programmable Modes: Counter, Period, Pulsewidth, Timing, Encoder

Frequency/Pulse Generators

Channels: 2 x 16-bit
Output Waveform: Square wave
Output Rate: 1 MHz base rate divided by 1 to 65,535 (programmable)
High-Level Output Voltage: 2.0 V min @ –1.0 mA; 2.9 V min @ –400 µA
Low-Level Output Voltage: 0.4 V max @ 400 µA

USB-1616HS Series

Specifications and Ordering

Input Sequencer

Analog, digital, and counter inputs can be scanned based on either an internal programmable timer or an external clock source.

Scan Clock Sources: two;

Internal, programmable:
Analog Channels from 1 µs to 19 hours in 20.83 ns steps
Digital Channels and Counters from 250 ns to 19 hours in 20.83 ns steps

External, TTL level input:
Analog Channels down to 1 µs min
Digital Channels and counters down to 250 ns min

Programmable Parameters per Scan: Channel (random order), gain

Depth: 512 locations

Onboard CH-CH Scan Rate/ External Input Scan Clock (APR) Max Rate

Analog: 1 MHz max

Digital: 4 MHz if no analog channels are enabled, 1 MHz with analog channels enabled

Clock Signal Range: Logical zero 0 V to 0.8 V; logical one 2.4 V to 5.0 V

Minimum Pulse Width: 50 ns high, 50 ns low

The maximum scan clock rate is the inverse of the minimum scan period. The minimum scan period is equal to 1 µs times the number of analog channels. If a scan contains only digital channels then the minimum scan period is 250 ns.

Triggering

Trigger Modes: individually selectable to start/stop an acquisition. Stop acquisition can occur on a different channel than start acquisition.
Single-channel analog hardware trigger, Single-channel analog software trigger, single-channel digital trigger, digital pattern trigger, counter/totalizer trigger, software trigger, multi-channel trigger

Environmental

Operating Temperature Range: –30 ˚C to 70 ˚C

Storage Temperature Range: —40 ˚C to 80 ˚C

Relative Humidity: 0% to 90% non-condensing max

Mechanical

Dimensions (L × W × H): 269 × 92 × 45 mm (10.6 × 3.6 × 1.6 in.)

Weight: 431 g (0.95 lb)

Vibration: MIL STD 810E Category 1 and 10

External Power

Connector: Switchcraft#RAPC-712

Power Range: 6 to 16 VDC (used when USB port supplies insufficient power, or when an independent power supply is desired)

Over-Voltage: 20 V for 10 seconds max

Expansion Connector: 25-pin D-SUB, female

Power Consumption

The included power adapter is required. By USB2 standards, USB2 ports are required to supply 2500 mW (nominal at 5 V, 500 mA).

USB-1616HS-2, USB-1616HS-4, USB-1616HS: 3000 mW
All models with the AI-EXP48: 3400 mW

Calibration

2 years recommended.

Ordering Information

Hardware

Part No.	Description
USB-1616HS	USB-based 16-bit, 1 MS/s multifunction device with 16 SE/8 DIFF analog inputs, four counters, two timers, and 24 DIO. Includes USB cable, external power supply, and MCC DAQ software.
USB-1616HS-2	USB-based 16-bit, 1 MS/s multifunction device with 16 SE/8 DIFF analog inputs, two analog outputs, four counter inputs, two timer outputs, and 24 digital I/O lines. Includes USB cable, external power supply, and MCC DAQ software.
USB-1616HS-4	USB-based 16-bit, 1 MS/s multifunction device with 16 SE/8 DIFF analog inputs, four analog outputs, four counter inputs, two timer outputs, and 24 digital I/O lines. Includes USB cable, external power supply, and MCC DAQ software.
DRM	DIN-Rail Mounting kit for the USB-1616HS Series
AI-EXP48	Analog input expansion module that provides an additional 48 analog inputs per device; channel features are identical to the main channels. Connection is via 25-pin D-SUB, female. Refer to the AI-EXP48 data sheet for complete specifications.

Note: For OEM and embedded applications, refer to the Measurement Computing USB-2500 Series.

Accessories and Cables

Part No.	Description
TR-2U	External replacement power supply, 100 to 240 VAC; requires additional cable: CA-1 (US) or CA-216 (European)
CA-96A	USB-1616HS Series to AI-EXP48 cable, 2 ft.
CN-153-12	Terminal block for USB-1616HS Series
745690-E001	E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-E002	E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-J001	J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-J002	J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-K001	K-type thermocouples wire, fiberglass (0 °C to 482 °C , 32 °F to 900 °F), 1 m
745690-K002	K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-T001	T-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-T002	T-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m

Software also Available from MCC

Part No.	Description
TracerDAQ Pro	Out-of-the-box virtual instrument suite with strip chart, oscilloscope, function generator, and rate generator – professional version
DASYLab	Icon-based data acquisition, graphics, control, and analysis software