# USB-1608G Series
## 16-Bit Multifunction DAQ Devices

## Features
- **16-bit high-speed USB devices**
- **Acquisition rates up to 500 kS/s**
- **8 differential (DIFF) or 16 single-ended (SE) analog inputs**
- **Two 16-bit analog outputs (USB-1608GX-2AO standard/OEM only)**
- **Eight individually-configurable digital I/O lines**
- **Two 32-bit counter inputs**
- **One timer output**
- **Available with enclosure and screw terminals, or as a board-only OEM version with header connectors (no case, CD, or USB cable included)**

## Software

### Supported Operating Systems
- **Windows 8/7/Vista®/XP 32/64-bit**
  - **Universal library (UL), ULx for NI LabVIEW™**
- **Linux® open-source driver support**
- **Android™**
  - **UL for Android**

### Ready-to-Run Applications
- **InstaCal™ (install, configure, and test)**
- **DAQami™ Advanced Data Logging Application (acquire, view, and log)**
- **TracerDAQ® (acquire, view, log, and generate)**

### Supported Programming Environments
- **Visual Studio® and Visual Studio .NET, including examples for Visual C++®, Visual C#®, Visual Basic®, and Visual Basic .NET, and other IDEs**
- **Java® (Android only) including examples and demo apps**
- **LabVIEW (Windows only)**
- **DASYLab®**
- **MATLAB® (Data Acquisition Toolbox™)**

## Overview
USB-1608G Series devices are low-cost, high-speed, analog and digital I/O USB devices. All of these devices offer up to eight DIFF or 16 SE analog inputs, eight digital I/O channels, two counter inputs, and one timer output.



*All USB-1608G Series devices offer 16 single-ended or eight differential analog inputs, 8 digital I/O, and one counter input. The USB-1608GX-2AO (shown here) also offers two analog outputs.*

| USB-1608G Series Selection Chart | | | | | |
|---|---|---|---|---|---|
| **Model** | **Analog Inputs** | **Sample Rate (max)** | **Analog Outputs** | **Signal I/O** | **USB Cable and SW CD** |
| USB-1608G | 16 SE/8 DIFF | 250 kS/s | 0 | Screw Terminal | ✔ |
| USB-1608GX | 16 SE/8 DIFF | 500 kS/s | 0 | Screw Terminal | ✔ |
| USB-1608GX-2AO | 16 SE/8 DIFF | 500 kS/s | 2 | Screw Terminal | ✔ |
| USB-1608G-OEM | 16 SE/8 DIFF | 250 kS/s | 0 | Header | – |
| USB-1608GX-OEM | 16 SE/8 DIFF | 500 kS/s | 0 | Header | – |
| USB-1608GX-2AO-OEM | 16 SE/8 DIFF | 500 kS/s | 2 | Header | – |

The USB-1608GX-2AO standard and OEM version offers two, 16-bit analog output channels with DAC rates up to 500 kS/s.

## Analog Input
USB-1608G Series devices provide 16-bit analog inputs that are software-selectable as eight DIFF or 16 SE inputs. These devices also support input ranges of ±10 V, ±5 V, ±2 V, and ±1 V that are software-selectable per channel.

## Analog Output (USB-1608GX-2AO only)
The USB-1608GX-2AO standard/OEM board has two 16-bit analog outputs that can be updated at a rate of 250 kS/s per channel; one output can be updated at a rate of 500 kS/s. The output range is fixed at ±10 V.

## Trigger Input
USB-1608G Series devices have an external digital trigger input. The trigger mode is software-selectable for edge- or level-sensitive mode. You can configure edge-sensitive mode for either rising or falling edge. In level-sensitive mode, you can configure for either high or low level. The default setting at power up is edge-sensitive, rising edge.
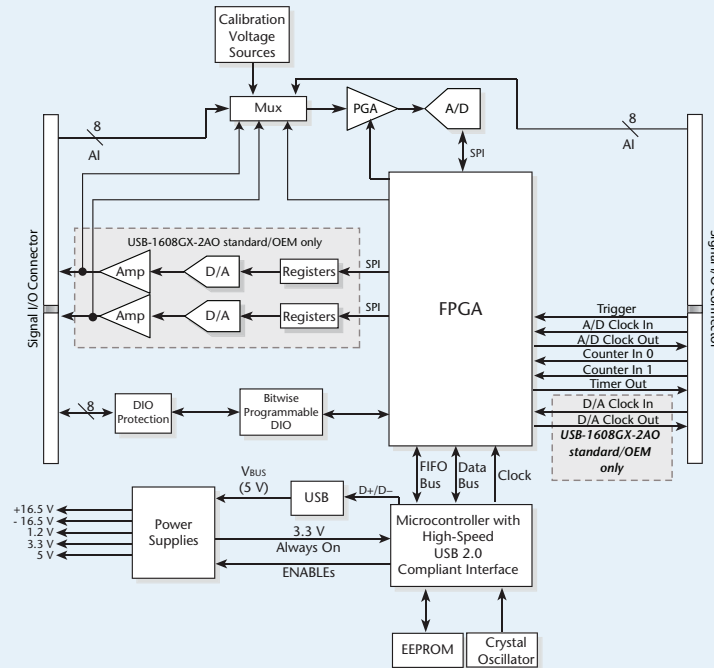
## Retrigger Mode
In retrigger mode, you can set up repetitive analog input trigger events. The trigger is automatically re-armed after it is activated. Use software to set the A/D trigger count (the number of samples you want per trigger).

# USB-1608G Series
## General Information



**USB-1608G Series Block Diagram**

## Digital I/O

Eight bidirectional digital I/O connections are individually configurable for input or output. The digital I/O terminals can detect the state of any TTL-level input. You can configure for pull-up (+5 V) or pull-down (0 V) with an onboard jumper.

## Counter Input

Two 32-bit event counters are provided to count TTL pulses. The counters accept inputs of up to 20 MHz.

## Timer Output

The PWM timer output generates a pulse output with a programmable frequency in the range of 0.0149 Hz to 32 MHz. The timer output parameters are software-selectable.

## Clock Output

The AI clock pin outputs the signal from the internal clock.

## Calibration

USB-1608G Series devices support field calibration. Run the InstaCal utility to calibrate the device whenever the ambient temperature changes by more than ±10 °C from the last field calibration. Calibrate the inputs before calibrating the outputs.

USB-1608G Series devices are factory-calibrated. Specifications are guaranteed for one year. For calibration beyond one year, return the device to the factory for recalibration.

## USB-1608G Series OEM Versions

OEM versions have board-only form factors with header connectors for OEM and embedded applications (no case, CD, or USB cable included). All devices can be further customized to meet customer needs.



*The OEM versions have the same specifications as the standard devices, but come in a board-only form factor with header connectors instead of screw terminals.*
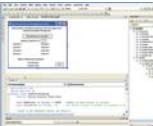
**MEASUREMENT COMPUTING**

## Software Support

USB-1608G Series devices are supported by the software in the table below.

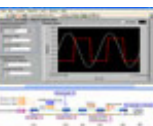| Ready-to-Run Applications | | |
|---|---|---|
| InstaCal | | An interactive utility that configures MCC hardware, and for supported devices, performs calibration tasks. Windows® OS<br><br>InstaCal is included with the free MCC DAQ Software bundle (CD/download). |
| DAQami | | Advanced data logging application with drag-and-drop software interface that is used to acquire, view, and log data. DAQami can be configured to log analog channels and to view that data in real-time or post-acquisition on user-configurable displays. Windows OS<br><br>DAQami is available as a purchased software download. |
| TracerDAQ and TracerDAQ Pro | | A virtual strip chart, oscilloscope, function generator, and rate generator applications used to generate, acquire, analyze, display, and export data. The Pro version provides enhanced features. Windows OS<br><br>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) | | Programming library of function calls for C, C++, VB, C# .Net, and VB .Net using Visual Studio and other IDEs. Windows OS<br><br>The UL is included with the free MCC DAQ Software bundle (CD/download). |
| UL for Android | | Programming library of function calls for Java programmers who develop apps for Android-based tablets and phones. UL for Android communicates with select MCC DAQ devices. Supports Android project development on Windows, Linux, Mac OS X<br><br>UL for Android is included with the free MCC DAQ Software bundle (CD/download). |
| Linux Driver | | Open-source Linux drivers are available for most MCC devices. Example programs are also provided. |
| **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<br><br>ULx is included with the free MCC DAQ Software bundle (CD/download). |
| DASYLab Driver | | Icon-based data acquisition, graphics, control, and analysis software that allows users to create complex applications in minimal time without text-based programming.<br><br>DASYLab is available as a purchased software download. Windows OS |
| MATLAB Driver | | High-level language and interactive environment for numerical computation, visualization, and programming. The Data Acquisition Toolbox, provided by The Mathworks, allows users to acquire data from most MCC PCI and USB devices.<br><br>Visit www.MathWorks.com for more information on MATLAB Data Acquisition Toolbox support. |

# USB-1608G Series
## Specifications

## Specifications

These specifications apply to both USB-1608G Series standard and OEM versions unless noted otherwise.

### Analog Input

**A/D Converter Type:** Successive approximation
**ADC Resolution:** 16 bits
**Number of Channels:** 8 DIFF, 16 SE; software-selectable
**Input Voltage Range:** ±10 V, ±5 V, ±2 V, ±1 V; software-selectable per channel
**Absolute Maximum Input Voltage**
  CHx Relative to AGND: ±25 V max (power on); ±15 V max (power off)
**Input Impedance:** 1 GΩ (power on); 820 Ω (power off)
**Input Bias Current:** ±10 nA
**Input Bandwidth**
  All Input Ranges, Small Signal (–3 dB)
    USB-1608G: 750 kHz
    USB-1608GX/1608GX-2AO: 870 kHz
**Input Capacitance:** 60 pf
**Maximum Working Voltage (Signal + Common Mode)**
  **±10 V Range:** ±10.2 V max relative to AGND
  **±5 V Range:** ±10.2 V max relative to AGND
  **±2 V Range:** ±9.5 V max relative to AGND
  **±1 V Range:** ±9.0 V max relative to AGND

**Common Mode Rejection Ratio**
  $f_{IN}$ = 60 Hz, All Input Ranges: 86 dB
**Crosstalk**
  **Adjacent Differential Mode Channels, DC to 100 kHz:** –75 dB
**Input Coupling:** DC
**Sampling Rate (Software-Selectable)**
  USB-1608G: 0.0149 Hz to 250 kHz
  USB-1608GX/1608GX-2AO: 0.0149 Hz to 500 kHz
**Trigger Source:** TRIG (refer to "External Trigger" on page 5)
**Sample Clock Source:** Internal A/D clock or external A/D clock (AICKI terminal)
**Burst Mode:** Software-selectable using the internal A/D clock; always enabled when using the external clock (AICKI terminal)
  USB-1608G: 4 µs
  USB-1608GX/1608GX-2AO: 2 µs
**Throughput**
  **Software Paced:** 33 to 4000 S/s typ, system dependent
  **Hardware Paced**
    USB-1608G: 250 kS/s max
    USB-1608GX/1608GX-2AO: 500 kS/s max
**Channel Gain Queue:** Up to 16 elements; software-selectable range for each channel
**Warm-up Time:** 15 minutes min

### Analog Input DC Voltage Measurement
All Values are (±)

| Range | Gain Error (% of Reading) | Offset Error (µV) | INL Error (% of Range) | Absolute Accuracy at Full Scale (µV) | Gain Temperature Coefficient (% reading/°C) | Offset Temperature Coefficient (µV/°C) |
|---|---|---|---|---|---|---|
| ±10 V | 0.024 | 915 | 0.0076 | 4075 | 0.0014 | 47 |
| ±5 V | 0.024 | 686 | 0.0076 | 2266 | 0.0014 | 24 |
| ±2 V | 0.024 | 336 | 0.0076 | 968 | 0.0014 | 10 |
| ±1 V | 0.024 | 245 | 0.0076 | 561 | 0.0014 | 5 |

### Noise Performance*

| Range | Counts | LSBrms |
|---|---|---|
| ±10 V | 6 | 0.91 |
| ±5 V | 6 | 0.91 |
| ±2 V | 7 | 1.06 |
| ±1 V | 9 | 1.36 |

\* For the peak-to-peak noise distribution test, a differential input channel is connected to AGND at the input terminal block, and 32,000 samples are acquired at the maximum rate available at each setting.

### Settling Time**
USB-1608G

| Range | 4 µS settling accuracy (% FSR) | 6 µS settling accuracy (% FSR) | 10 µS settling accuracy (% FSR) |
|---|---|---|---|
| ±10 V | 0.0061 | 0.0031 | 0.0015 |
| ±5 V | 0.0061 | 0.0031 | 0.0015 |
| ±2 V | 0.0061 | 0.0031 | 0.0015 |
| ±1 V | 0.0061 | 0.0031 | 0.0015 |

### Settling Time**
USB-1608GX/1608GX-2AO

| Range | 2 µS settling accuracy (% FSR) | 4 µS settling accuracy (% FSR) | 9 µS settling accuracy (% FSR) |
|---|---|---|---|
| ±10 V | 0.1251 | 0.0031 | 0.0015 |
| ±5 V | 0.0687 | 0.0031 | 0.0015 |
| ±2 V | 0.0687 | 0.0031 | 0.0015 |
| ±1 V | 0.0687 | 0.0031 | 0.0015 |

\*\* Settling time is defined as the expected accuracy after one conversion when switching from a channel with a DC input at one extreme of full scale to another channel with a DC input at the other extreme of full scale. Both input channels are configured for the same input range.

### Analog Output (USB-1608GX-2AO only)

**Number of Channels:** 2 (leave unused AOUTx output channels disconnected)
**Resolution:** 16 bits
**Output Range:** ±10 V (calibrated)
**Output Transient**
  Host computer is reset, powered on, suspended, or a reset command is issued to the device.
    **Duration:** 500 µs
    **Amplitude:** 2 V pk-pk
  **Powered Off**
    **Duration:** 10 ms
    **Amplitude:** 7 V peak
**Differential Non-Linearity:** ±0.25 LSB typ; ±1 LSB max
**Output Current**
  **AOUTx:** ±3.5 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 (AOUTx defaults to 0 V whenever the host computer is reset, powered on, suspended, or a reset command is issued to the device)
**Output Noise:** 30 µVrms
**Trigger Source:** TRIG (refer to "External Trigger" on page 5)
**Sample Clock Source:** Internal D/A clock or external D/A clock (AOCKI terminal)
**Output Update Rate:** 500 kHz/number of channels in the scan
**Settling Time**
    **To Rated Accuracy, 10 V Step:** 40 µs
**Slew Rate:** 9 V/µs
**Throughput**
    **Software Paced:** 33 S/s to 4000 S/s typ, system-dependent
    **Hardware Paced:** 500 kS/s max, system-dependent

## Calibrated Absolute Accuracy

**Range:** ±10 V
**Absolute Accuracy ( ± LSB):** 16.0

## Calibrated Absolute Accuracy Components

**Range:** ±10 V
**% of Reading:** ±0.0183
**Offset (±mV):** 1.831
**Offset Tempco (µV/°C):** 12.7
**Gain Tempco (ppm of Range/°C):** 13

## Analog Output Relative Accuracy

**Range:** ±10 V
**Relative Accuracy (INL):** 4.0 typ

## Analog Input/Output Calibration

**Recommended Warm-Up Time:** 15 minutes min
**Calibration Method:** Self-calibration (firmware)
**Calibration Interval:** 1 year (factory calibration)
**AI Calibration Reference**
    +5 V, ±2.5 mV max (actual measured values stored in EEPROM)
    **Tempco:** 5 ppm/°C max
    **Long Term Stability:** 15 ppm/1000 hours
**AOUTx Calibration Procedure** (USB-1608GX-2AO only)
    The AOUTx terminals are internally routed to the analog input circuit. For best calibration results, disconnect any AOUTx connections at the terminal block prior to performing AOUT calibration.

## Digital I/O

**Digital Type:** CMOS
**Number of I/O:** 8
**Configuration:** Bit-configurable as input (power on default) or output
**Pull-Up Configuration:** The port has 47 kΩ resistors configurable as pull-ups or pull-downs (default) via internal jumper (W1).
**Digital I/O Transfer Rate (System-Paced):** 33 to 8000 port reads/writes or single bit reads/writes per second typ, system dependent.
**Input High Voltage:** 2.0 V min, 5.5 V absolute max
**Input Low Voltage:** 0.8 V max, –0.5 V absolute min, 0 V recommended min
**Output High Voltage:** 4.4 V min (IOH = –50 µA), 3.76 V min (IOH = –2.5 mA)
**Output Low Voltage:** 0.1 V max (IOL = 50 µA), 0.44 V max (IOL = 2.5 mA)
**Output Current:** ±2.5 mA max

## External Trigger

**Trigger Source:** TRIG input
**Trigger Mode:** Software configurable for edge or level sensitive, rising or falling edge, high or low level. Power on default is edge sensitive, rising edge.
**Trigger Latency:** 1 µs + 1 clock cycle max
**Trigger Pulse Width:** 100 ns min
**Input Type:** Schmitt trigger, 33 Ω series resistor and 49.9 kΩ pull-down to ground
**Schmitt Trigger Hysteresis:** 0.4 V to 1.2 V
**Input High Voltage:** 2.2 V min, 5.5 V absolute max
**Input Low Voltage:** 1.5 V max, –0.5 V absolute min, 0 V recommended min

## External Clock I/O

**Terminal Names**
    AICKI, AICKO
    USB-1608GX-2AO: AICKI, AICKO AOCKI, AOCKO
**Terminal Types**
    **AxCKI:** Input, active on rising edge
    **AxCKO:** Output, power on default is 0 V, active on rising edge
**Terminal Descriptions**
    **AxCKI:** Receives sampling clock from external source
    **AxCKO:** Outputs the internal sampling clock (D/A or A/D clock) or the pulse generated from AxCKI when in external clock mode.
**Input Clock Rate**
    **USB-1608G:** 250 kHz max
    **USB-1608GX/1608GX-2AO:** 500 kHz max
**Clock Pulse Width**
    **AxCKI:** 400 ns min
    **AxCKO:** 400 ns min
**Input Type:** Schmitt trigger, 33 Ω series resistor, 47 kΩ pull-down to ground
**Schmitt Trigger Hysteresis:** 0.4 V to 1.2 V
**Input High Voltage:** 2.2 V min, 5.5 V absolute max
**Input Low Voltage:** 1.5 V max, –0.5 V absolute min, 0 V recommended min
**Output High Voltage:** 4.4 V min (IOH = –50 µA), 3.76 V min (IOH = –2.5 mA)
**Output Low Voltage:** 0.1 V max (IOL = 50 µA), 0.44 V max (IOL = 2.5 mA)
**Output Current:** ±2.5 mA max

## Counter Input

**Terminal Names:** CTR0, CTR1
**Number of Channels:** 2 channels
**Resolution:** 32-bit
**Counter Type:** Event counter
**Input Type:** Schmitt trigger, 33 Ω series resistor, 47 kΩ pull-down to ground
**Input Source:**
    CTR0 (terminal 52)
    CTR1 (terminal 51)
**Counter Read/Writes Rates (Software-Paced) :** 33 to 8000 reads/writes per second typ, system dependent
**Input High Voltage:** 2.2 V min, 5.5 V max
**Input Low Voltage:** 1.5 V max, –0.5 V min
**Schmitt Trigger Hysteresis:** 0.4 V min, 1.2 V max
**Input Frequency:** 20 MHz, max
**High Pulse Width:** 25 ns, min
**Low Pulse Width:** 25 ns, min

## Timer Output

**Timer Terminal Name:** TMR
**Timer Type:** PWM output with count, period, delay, and pulse width registers
**Output Value:** Default state is idle low with pulses high, software-selectable output invert
**Internal Clock Frequency:** 64 MHz
**Register Widths:** 32-bit
**High Pulse Width:** 15.625 ns min
**Low Pulse Width:** 15.625 ns min
**Output High Voltage:** 4.4 V min (IOH = –50 µA), 3.76 V min (IOH = –2.5 mA)
**Output Low Voltage:** 0.1 V max (IOL = 50 µA), 0.44 V max (IOL = 2.5 mA)
**Output Current:** ±2.5 mA max

## Memory

**Data FIFO:**
    **USB-1608G/1608GX:** 4 kS analog input
    **USB-1608GX-2AO:** 4 kS analog input, 2 kS analog output
**Non-Volatile Memory:** 32 KB (28 KB firmware storage, 4 KB calibration/user data)

# USB-1608G Series
## Ordering Information

## Power

**Supply Current**
This is the total quiescent current requirement and includes up to 10 mA for the Status LED. This does not include any potential loading of the digital I/O bits, +5 V terminal, or the AOUTx outputs (USB-1608GX-2AO only).

    **Quiescent Current**
        **USB-1608G/1608GX:** 230 mA
        **USB-1608GX-2AO:** 260 mA

**+5 V User Output Voltage Range (Available at Terminal 43):** 4.5 V min to 5.25 V max

**+5 V User Output Current** (**Available at Terminal 43):** 10 mA max

## Environmental

**Operating Temperature Range:** 0 °C to 55 °C max
**Storage Temperature Range:** –40 °C to 85 °C max
**Humidity:** 0% to 90% non-condensing max

## Mechanical

**Signal I/O Connector**
    **-OEM Models:** Two 28-pin, 0.1 in. pitch headers
    **All Other Devices:** 2 banks of screw-terminal blocks (wire gauge range 16 AWG to 30 AWG)

**Dimensions (L × W × H):**
    **Standard Version:** 127 × 89.9 × 35.6 mm (5.00 × 3.53 × 1.40 in.)
    **OEM Version:** 121.92 × 86.36 × 15.24 (4.80 × 3.40 × 0.60 in.)

## Ordering Information

| Part No. | Description |
|---|---|
| USB-1608G | 16-channel, 250 kS/s device with two 32-bit counter inputs, one timer output, and eight DIO lines. Includes USB cable and MCC DAQ software CD. |
| USB-1608GX | 16-channel, 500 kS/s device with two 32-bit counter inputs, one timer output, and eight DIO lines. Includes USB cable and MCC DAQ software CD. |
| USB-1608GX-2AO | 16-channel, 500 kS/s device with two analog outputs, two 32-bit counter inputs, one timer output, and eight DIO lines. Includes USB cable and MCC DAQ software CD. |
| USB-1608G-OEM | Board-only USB-based DAQ device with 16-channels, 250 kS/s sampling, two 32-bit counter inputs, one timer output, and eight DIO lines. |
| USB-1608GX-OEM | Board-only USB-based DAQ device with 16-channel, 500 kS/s sampling, two 32-bit counter inputs, one timer output, and eight DIO lines. |
| USB-1608GX-2AO-OEM | Board-only USB-based DAQ device with 16-channels, 500 kS/s sampling, two analog outputs, two 32-bit counter inputs, one timer output, and eight DIO lines. |

## Software also Available from MCC

| | |
|---|---|
| DAQami | Easy-to-use advanced data logging software to acquire, view, and log data |
| 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 |