# USB-1608HS-2AO

## Specifications

# Specifications

**Typical for 25 °C unless otherwise specified.**

**Specifications in *italic text* are guaranteed by design.**

## Analog input

Table 1. Analog input specifications

| Parameter | Conditions | Specification |
|---|---|---|
| A/D converter type | | 16-bit successive approximation type |
| Number of channels | | Eight differential |
| | | Eight single-ended |
| Input configuration | | Individual A/D per channel |
| Sampling method | | Simultaneous |
| Analog input modes | Power up and reset state | CHx_H and CHx_L inputs are disconnected from their screw terminal pins and internally connected to GND (recommended configuration for unused inputs). |
| | Single-ended | CHx_H inputs are connected directly to their screw terminal pins. |
| | | CHx_L inputs are disconnected from their screw terminal pins and internally connected to GND. |
| | Differential | CHx_H and CHx_L inputs are connected directly to their screw terminal pins. |
| *Absolute maximum input voltage* | *CHx IN to GND.* | *±25 V maximum (power on)* |
| | *TRIG_IN to GND* | *±15 V maximum (power off)* |
| *Input impedance* | *CHx IN* | *1 GΩ (power on)* |
| | | *1.5 kΩ (power off)* |
| Input bandwidth (-3 dB) | All input ranges | 330 kHz |
| *Input leakage current* | | *±25 pA* |
| *Input capacitance* | | *50 pf* |
| Input ranges | Software-selectable per channel | ±10 V, ±5 V, ±2 V, ±1 V |
| A/D pacing | | Onboard A/D clock, external source (SYNC_IN). See Table 9 on page 5. |
| A/D trigger source | | TRIG_IN input. See Table 8 on page 4. |
| A/D trigger modes | | External analog. See Table 8 on page 4. |
| Maximum working voltage (signal + common mode) | | ±0.05% FSR maximum. |
| Sampling rate | | 0.009 S/s to 250 kS/s, software-programmable |
| Throughput | Software-paced | 33 to 8000 S/s all channels, system-dependent |
| | Scan to PC memory | 250 kS/s per channel maximum (throughput rate may be limited on USB 1.1 ports). |
| Resolution | | 16 bits |
| Differential non-linearity (Note 1) | Calibrated | ±2.0 |
| | Un-calibrated | ± 0.5 LSB typical. |
| | | ±1.0 LSB maximum. |
| *CMRR (60 Hz)* | *±10 V range* | *81 db minimum* |
| | *±5 V range* | *81 db minimum* |
| | *±2 V range* | *92 db minimum* |
| | *±1 V range* | *92 db minimum* |

**Note 1:** The maximum differential non-linearity specification applies to the entire 0-55 °C temperature range of the USB-1608HS-2AO. This specification also accounts for the maximum errors due to the software calibration (in Calibrated mode only) and the AD7685 analog to digital converter non-linearities.

Table 2. Calibrated absolute accuracy

| Range | Accuracy (mV) |
|---|---|
| ±10 V | ± 7.019 |
| ±5 V | ± 3.509 |
| ±2 V | ± 1.403 |
| ±1 V | ± 0.702 |

Table 3. Accuracy components - All values are (±)

| Range | Integral Non Linearity (% FSR) | Gain error at FS (mV) | Offset (mV) | Gain tempco (ppm/°C) | Offset tempco (µV/°C) |
|---|---|---|---|---|---|
| ±10 V | 0.00915 | 4.578 | 1.526 | 3.8 | 19.5 |
| ±5 V | 0.00915 | 2.289 | 0.763 | 7.0 | 19.5 |
| ±2 V | 0.00915 | 0.916 | 0.305 | 16.5 | 24.3 |
| ±1 V | 0.00915 | 0.458 | 0.153 | 40.1 | 29.2 |

**Note 2:** When connecting differential inputs to floating input sources, the user must provide a DC return path from each differential input to ground. This can be accomplished by simply connecting a resistor from each of the differential inputs to AGND. A value of approximately 100 kΩ can be used for most applications.

Table 4. Noise performance – all values are (±)

| Range | Peak to Peak Noise (counts) | RMS noise LSBrms |
|---|---|---|
| ±10 V | 8 | 1.21 |
| ±5 V | 8 | 1.21 |
| ±2 V | 8 | 1.21 |
| ±1 V | 8 | 1.21 |

Table 4 summarizes the noise performance for the USB-1608HS-2AO. Noise distribution is determined by gathering 50 kS with inputs tied to ground at the user connector. Samples are gathered at the maximum specified sampling rate of 250 kS/s.

# Analog output

Table 5. Analog output specifications

| Parameter | Conditions | Specifications |
|---|---|---|
| Number of channels | | Two independent |
| Resolution | | 16 bits |
| Output range | | ±10 V |
| Throughput | Single channel | 70 kS/s |
| | Two channel | 35 kS/s |
| Pacer source | | Onboard D/A clock |
| *Monotonicity* | | *16 bits* |
| *Glitch energy* | | *200 nV/s* |
| Current output (Note 3) | | ±10 mA maximum single channel |
| | | ±20 mA maximum two channels |
| Output short-circuit protection | Output connect to GND | 100 mS maximum |
| Output coupling | | DC |
| Power up and reset state | | DACs clear to midscale, (0 V, ±20 mV). Remote sense is disabled. |
| Remote sense configuration | | Enabled or disabled through software control. |
| Remote sense compliance voltage (Note 4) | | ±10.75 V maximum |
| Remote sense compensation range (Note 5) | | 0 to 75 Ω maximum |
| *Output noise* | | *100 nV/Hz* |
| *Settling time (to 0.003%)* | *20 V output step, (RL=5 kΩ, CL=200 pf)* | *5 µS maximum* |
| Slew rate | | 10 V/µs |
| Absolute accuracy | | ±0.25% of FSR maximum |
| Offset error drift | | ±4 ppm/°C |
| Gain error drift | | ±10 ppm/°C |

**Note 3:** The maximum load that the analog output can drive is calculated by dividing the full-scale output voltage by the current output specification or (10 V/10 mA) = 1000 Ω. This calculation is valid whether the Remote Sense feature is enabled or disabled.

**Note 4:** The USB-1608HS-2AO Remote Sense feature can compensate for any series resistance up to 75 Ω between its force terminal pins and its output load.

**Note 5:** Rload should not exceed the specified 1000 Ω, and the Rseries should not exceed its specified limit of 75 Ω.

## Analog input calibration

Table 6. Analog input calibration specifications

| Parameter | Specifications |
|---|---|
| Recommended warm-up time | 15 minutes minimum |
| Calibration method | Software calibration |
| Calibration interval | 1 year |
| Calibration reference | +10.000 V, ±5 mV maximum. Actual measured values stored in EEPROM |
| | Tempco: 5 ppm/°C maximum |
| | Long term stability: 30 ppm/1000 h |

## Digital input/output

Table 7. Digital I/O specifications

| | |
|---|---|
| Digital type | 5 V CMOS |
| Number of I/O | 16 |
| Configuration | Eight input, eight output |
| Pull-up/pull-down configuration | The eight input pins have 47 k resistors that may be configured to either pull-up or pull-down with a jumper |
| Digital I/O transfer rate (system-paced) | System-dependent, 33 to 8000 port reads/writes or single bit reads/writes per second. |
| Input high voltage | 2.0 V minimum, 5.5 V absolute maximum |
| Input low voltage | 0.8 V maximum, –0.5 V absolute minimum |
| Output high voltage (IOH = –2.5 mA) | 3.8 V minimum |
| Output low voltage (IOL = 2.5 mA) | 0.7 V maximum |
| Power on and reset state | Outputs: driven low |
| LED indicators | Each I/O pin has an associated LED status indicator. A high at the pin will cause the LED to be on. The LEDs may be disabled with jumpers - one jumper for the input LEDs (JP1), and one jumper for the output LEDs (JP2). |

## External trigger

Table 8. External trigger specifications

| Parameter | Conditions | Specification |
|---|---|---|
| Trigger source | | TRIG_IN input |
| Trigger input range | | ±10 V maximum. |
| *Absolute maximum input voltage* | *TRIG_IN to GND* | *±25 V maximum (power on)* |
| | | *±15 V maximum (power off)* |
| Trigger threshold levels | | ±10V/4096; Software configurable |
| *Input impedance* | | *1 MΩ (power on)* |
| | | *1.5 kΩ (power off)* |
| Trigger modes | | Software configurable for:<br>▪ Positive or negative slope<br>▪ Edge/level<br>▪ Retrigger |
| Threshold resolution | | 12 bits, 1 in 4096 |
| Threshold accuracy | | ±0.25% FSR |
| Hysteresis | | ±5 mV |
| Full power bandwidth (-3 dB) | | 640 kHz |

# External clock input/output

Table 9. External clock I/O specifications

| Parameter | Conditions | Specification |
|---|---|---|
| Pin names | | SYNC_IN, SYNC_OUT |
| Pin type | | SYNC_IN: Input<br>SYNC_OUT: Output |
| Pin descriptions | SYNC_OUT | Outputs A/D pacer clock. |
| | SYNC_IN | Receives A/D pacer clock from external source.<br>Rising edge sensitive. |
| Input clock rate | | 250 kHz maximum. |
| Clock pulse width | SYNC_IN | 1 µs minimum |
| | SYNC_OUT | 2 µs minimum |
| *Input leakage current* | | *±2.0 µA* |
| Input high voltage | | 3.5 V minimum, 6.5 V absolute maximum |
| Input low voltage | | 1.5 V maximum, –0.5 V absolute minimum |
| Output high voltage (Note 6) | IOH = –2.5 mA | 3.3 V minimum |
| | No load | 3.8 V minimum |
| Output low voltage (Note 6) | IOL = 2.5 mA | 1.1 V maximum |
| | No load | 0.6 V maximum |

**Note 6:** SYNC_OUT is over-current protected with a 200 Ω series resistor.

# Counter

Table 10. Counter specifications

| Pin name (Note 7) | CTR |
|---|---|
| Counter type | Event counter |
| Number of channels | 1 |
| Input type | TTL, rising edge triggered |
| Input source | CTR screw terminal |
| Resolution | 32 bits |
| *Schmidt trigger hysteresis* | *0.58 V to 0.93 V* |
| *Input leakage current* | *±5 µA* |
| Maximum input frequency | 1 MHz |
| *High pulse width* | *500 ns minimum* |
| *Low pulse width* | *500 ns minimum* |
| Input high voltage | 2.4 V minimum, 6.5 V absolute maximum |
| Input low voltage | 2.19 V maximum, –0.5 V absolute minimum |

**Note 7:** CTR is a Schmitt trigger input protected with a 1 kΩ series resistor.

# Memory

Table 11. Memory specifications

| Data FIFO | 65536 samples, 131,072 bytes |
|---|---|
| EEPROM | 512 bytes |

## Microcontroller

Table 12. Microcontroller specifications

| *Type* | *High performance 8-bit RISC microcontroller* |
|---|---|
| *Program memory* | *16,384 words* |
| *Data memory* | *2,048 bytes* |

## Power

Table 13. Power specifications

| Parameter | Conditions | Specification |
|---|---|---|
| Supply current (see Note 8) | Continuous mode | 920 mA |
| +5V EXT output voltage range (see Note 9) | | 4.5 V minimum, 5.25 V maximum |
| +5V EXT output current (see Note 10) | | +10 mA maximum |

**Note 8:** This is the total current requirement for the USB-1608HS-2AO. This specification does not include any additional contribution due to +5VEXT output current, analog output source current, or DIO loading.

**Note 9:** Output voltage range assumes input power supply is within specified limits.

**Note 10:** This refers to the total amount of current that can be sourced from the +5VEXT terminal pin for general use.

## External power input

Table 14. External power input specifications

| External power input | +5.0 VDC (+5 V power supply included) |
|---|---|
| External power adapter | +5 V, ±5% @ 2 A |

## USB specifications

Table 15. USB specifications

| USB device type | USB 2.0 (high-speed) |
|---|---|
| USB device compatibility | USB 1.1, 2.0 |
| USB cable length | Three meters maximum. |
| USB cable type | A-B cable, UL type AWM 2527 or equivalent (minimum 24 AWG VBUS/GND, minimum 28 AWG D+/D-). |

## Environmental

Table 16. Environmental specifications

| Operating temperature range | 0 to 55 °C maximum |
|---|---|
| Storage temperature range | -40 to 85 °C maximum |
| Humidity | 0 to 90% non-condensing |

# Mechanical

Table 17. Mechanical specifications

| Card dimensions | 203.2 mm (L) x 121.9 mm (W) x 20.0 mm (H) |
|---|---|
|  | 8.0" (L) x 4.8" (W) x 0.8" (H) |
| Enclosure dimensions | 241.3 mm (L) x 125.7 mm (W) x 58.9 mm (H) |
|  | 9.50" (L) x 4.95" (W)x 2.32" (H) |

# Main connector and pin out

Table 18. Main connector specifications

| Connector type | Screw terminal |
|---|---|
| Wire gauge range | 16 AWG to 30 AWG |

Table 19. Main connector pin out, 8-channel differential mode

| Pin | Signal name | Pin | Signal name |
|---|---|---|---|
| 1 | GND | 28 | VDAC1_F |
| 2 | DI0 | 29 | VDAC1_S |
| 3 | DI1 | 30 | AGND |
| 4 | DI2 | 31 | CH0_L |
| 5 | DI3 | 32 | CH0_H |
| 6 | DI4 | 33 | AGND |
| 7 | DI5 | 34 | CH1_L |
| 8 | DI6 | 35 | CH1_H |
| 9 | DI7 | 36 | AGND |
| 10 | GND | 37 | CH2_L |
| 11 | DO0 | 38 | CH2_H |
| 12 | DO1 | 39 | AGND |
| 13 | DO2 | 40 | CH3_L |
| 14 | DO3 | 41 | CH3_H |
| 15 | DO4 | 42 | AGND |
| 16 | DO5 | 43 | CH4_L |
| 17 | DO6 | 44 | CH4_H |
| 18 | DO7 | 45 | AGND |
| 19 | GND | 46 | CH5_L |
| 20 | SYNC_IN | 47 | CH5_H |
| 21 | SYNC_OUT | 48 | AGND |
| 22 | +5V EXT | 49 | CH6_L |
| 23 | CTR | 50 | CH6_H |
| 24 | TRIG_IN | 51 | AGND |
| 25 | VDAC0_F | 52 | CH7_L |
| 26 | VDAC0_S | 53 | CH7_H |
| 27 | AGND | 54 | AGND |

Table 20. Main connector pin out, 8-channel single-ended mode

| Pin | Signal name | Pin | Signal name |
|-----|-------------|-----|-------------|
| 1 | GND | 28 | VDAC1_F |
| 2 | DI0 | 29 | VDAC1_S |
| 3 | DI1 | 30 | AGND |
| 4 | DI2 | 31 | NC |
| 5 | DI3 | 32 | CH0_H |
| 6 | DI4 | 33 | AGND |
| 7 | DI5 | 34 | NC |
| 8 | DI6 | 35 | CH1_H |
| 9 | DI7 | 36 | AGND |
| 10 | GND | 37 | NC |
| 11 | DO0 | 38 | CH2_H |
| 12 | DO1 | 39 | AGND |
| 13 | DO2 | 40 | NC |
| 14 | DO3 | 41 | CH3_H |
| 15 | DO4 | 42 | AGND |
| 16 | DO5 | 43 | NC |
| 17 | DO6 | 44 | CH4_H |
| 18 | DO7 | 45 | AGND |
| 19 | GND | 46 | NC |
| 20 | SYNC_IN | 47 | CH5_H |
| 21 | SYNC_OUT | 48 | AGND |
| 22 | +5V EXT | 49 | NC |
| 23 | CTR | 50 | CH6_H |
| 24 | TRIG_IN | 51 | AGND |
| 25 | VDAC0_F | 52 | NC |
| 26 | VDAC0_S | 53 | CH7_H |
| 27 | AGND | 54 | AGND |

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