NI USB-621x Specifications

Specifications listed below are typical at 25 °C unless otherwise noted.

**Analog Input**

Number of channels
- USB-6210/6211/6215................. 8 differential or 16 single ended
- USB-6218............................ 16 differential or 32 single ended

ADC resolution......................... 16 bits

DNL ........................................ No missing codes guaranteed

INL........................................... Refer to the *AI Absolute Accuracy Table*

**Sampling rate**
- Maximum ................................ 250 KS/s (aggregate)
- Minimum ................................. 0 S/s
- Timing accuracy ...................... 50 ppm of sample rate
- Timing resolution ................. 50 ns

Input coupling ........................... DC

Input range............................... ±10 V, ±5 V, ±1 V, ±0.2 V

Maximum working voltage for analog inputs
(signal + common mode)............... ±10.4 V of AI GND

CMRR (DC to 60 Hz).................... 100 dB

Input impedance
- Device on
  - AI+ to AI GND ...................... >10 GΩ in parallel with 100 pF
  - AI– to AI GND ...................... >10 GΩ in parallel with 100 pF
- Device off
  - AI+ to AI GND ...................... 1200 Ω
  - AI– to AI GND ...................... 1200 Ω

Input bias current...................... ±100 pA

Crosstalk (at 100 kHz)
- Adjacent channels.................... -75 dB
- Non-adjacent channels ............. -90 dB

Small signal bandwidth (~3 dB)....... 450 kHz

Input FIFO size.......................... 4,095 samples

Scan list memory ...................... 4,095 entries

Data transfers........................... USB Signal Stream, programmed I/O

Overvoltage protection (AI <0..31>, AI SENSE)
- Device on ............................. ±30 V for up to two AI pins
- Device off ............................. ±20 V for up to two AI pins

Input current during overvoltage condition............... ±20 mA max/AI pin

**Settling Time for Multichannel Measurements**

Accuracy, full scale step, all ranges
- ±90 ppm of step (±6 LSB) .......... 4 μs convert interval
- ±30 ppm of step (±2 LSB) .......... 5 μs convert interval
- ±15 ppm of step (±1 LSB) .......... 7 μs convert interval
Typical Performance Graphs

Analog Output

Number of channels
USB-6210............................ 0
USB-6211/6215/6218.............. 2

DAC resolution.......................... 16 bits
DNL ........................................... ±1 LSB
Monotonicity ................................ 16 bit guaranteed

Maximum update rate
1 channel ................................ 250 kS/s
2 channels................................ 250 kS/s per channel

Timing accuracy ............................ 50 ppm of sample rate
Timing resolution .......................... 50 ns

Output range ................................ ±10 V
Output coupling ......................... DC

Output impedance.......................... 0.2 Ω
Output current drive ...................... ±2 mA
Overdrive protection ..................... ±30 V

Overdrive current ........................ 2.4 mA
Power-on state .......................... ±20 mV
Power-on glitch .......................... ±1 V for 200 ms

Output FIFO size ......................... 8,191 samples shared among channels used

Data transfers ................................ USB Signal Stream, programmed I/O

AO waveform modes:
• Non-periodic waveform
• Periodic waveform regeneration mode from onboard FIFO
• Periodic waveform regeneration from host buffer including dynamic update

Settling time, full scale step
15 ppm (1 LSB) ....................... 32 μs

Slew rate .......................... 10 V/μs

Glitch energy
Magnitude .......................... 100 mV
Duration ................................ 2.6 μs

Calibration (AI and AO)

Recommended warm-up time .......... 15 minutes

Calibration interval ..................... 1 year
### AI Absolute Accuracy Table

<table>
<thead>
<tr>
<th>Nominal Range</th>
<th>Residual Gain Error (ppm of Reading)</th>
<th>Gain Tempco (ppm/°C)</th>
<th>Reference Tempco</th>
<th>Residual Offset Error (ppm of Range)</th>
<th>Offset Tempco (ppm of Range)</th>
<th>INL Error (ppm of Range)</th>
<th>Random Noise, σ (μVrms)</th>
<th>Absolute Accuracy at Full Scale1 (μV)</th>
<th>Sensitivity2 (μV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Full Scale</td>
<td>10</td>
<td>75</td>
<td>7.3</td>
<td>5</td>
<td>20</td>
<td>34</td>
<td>76</td>
<td>229</td>
<td>2,690</td>
</tr>
<tr>
<td>Negative Full Scale</td>
<td>5</td>
<td>5</td>
<td>85</td>
<td>7.3</td>
<td>5</td>
<td>20</td>
<td>36</td>
<td>76</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>95</td>
<td>7.3</td>
<td>5</td>
<td>25</td>
<td>49</td>
<td>76</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>0.2</td>
<td>135</td>
<td>7.3</td>
<td>5</td>
<td>40</td>
<td>116</td>
<td>76</td>
<td>12</td>
</tr>
</tbody>
</table>

Absolute Accuracy = Reading · (Gain Error) + Range · (Offset Error) + Noise Uncertainty

Gain Error = Residual AIGain Error + Gain Tempco · (Temp Change From Last Internal Cal) + Reference Tempco · (Temp Change From Last External Cal)

Offset Error = Residual AIOffset Error + Offset Tempco · (Temp Change From Last Internal Cal) + INL Error

Noise Uncertainty = \[ \frac{Random Noise \cdot 3}{\sqrt{100}} \]

For a coverage factor of 3 \( \sigma \) and averaging 100 points.

1 Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

- Temp Change From Last External Cal = 10 °C
- Temp Change From Last Internal Cal = 1 °C
- Number of readings = 100
- Coverage Factor = 3 \( \sigma \)

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

- Gain Error = 75 ppm + 7.3 ppm · 1 + 5 ppm · 10 = 132 ppm
- Offset Error = 20 ppm + 34 ppm · 1 + 76 ppm = 130 ppm
- Noise Uncertainty = \( \frac{229 \mu V \cdot 3}{\sqrt{100}} \) = 68.7 \( \mu V \)

Absolute Accuracy = 10 V · (Gain Error) + 10 V · (Offset Error) + Noise Uncertainty = 2,690 \( \mu V \)

2 Sensitivity is the smallest voltage change that can be detected. It is a function of noise.

Accuracies listed are valid for up to one year from the device external calibration.
### AO Absolute Accuracy Table

<table>
<thead>
<tr>
<th>Nominal Range</th>
<th>Residual Gain Error (ppm of Reading)</th>
<th>Gain Tempco (ppm/°C)</th>
<th>Reference Tempco</th>
<th>Residual Offset Error (ppm of Range)</th>
<th>Offset Tempco (ppm of Range/°C)</th>
<th>INL Error (ppm of Range)</th>
<th>Absolute Accuracy at Full Scale¹ (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Full Scale</td>
<td>-10</td>
<td>90</td>
<td>11</td>
<td>5</td>
<td>60</td>
<td>12</td>
<td>128</td>
</tr>
<tr>
<td>Negative Full Scale</td>
<td>-10</td>
<td>90</td>
<td>11</td>
<td>5</td>
<td>60</td>
<td>12</td>
<td>128</td>
</tr>
</tbody>
</table>

¹ Absolute Accuracy at full scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration. Accuracies listed are valid for up to one year from the device external calibration.

Absolute Accuracy = OutputValue · (GainError) + Range · (OffsetError)

GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + AOOffsetTempco · (TempChangeFromLastInternalCal) + INL_Error
Digital I/O/PFI

Static Characteristics

Number of channels
- Digital input
  - USB-6210/6211/6215 ............ 4 (PFI <0..3>/P0.<0..3>)
  - USB-6218 .............................. 8 (PFI <0..3>/P0.<0..3>, PFI <8..11>/P0.<4..7>)
- Digital output
  - USB-6210/6211/6215 ............ 4 (PFI <4..7>/P1.<0..3>)
  - USB-6218 .............................. 8 (PFI <4..7>/P1.<0..3>, PFI <12..15>/P1.<4..7>)
- Ground reference ............................ D GND
- Pull-down resistor ........................... 47 kΩ ±1%
- Input voltage protection1 ................. ±20 V on up to 8 pins

PFI/Port 0/Port 1 Functionality
- PFI <0..3>, PFI <8..11>/Port 0
  - Functionality ......................... Static digital input, timing input
  - Debounce filter settings ............... 125 ns, 6.425 μs, 2.54 ms, disable; high and low transitions; selectable per input
- PFI <4..7>, PFI <12..15>/Port 1
  - Functionality ............................ Static digital output, timing output
  - Timing output sources ................. Many AI, AO, counter timing signals

Maximum Operation Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_{OL} output low current</td>
<td></td>
<td>—</td>
<td>16 mA</td>
</tr>
<tr>
<td>I_{OH} output high current</td>
<td></td>
<td>—</td>
<td>−16 mA</td>
</tr>
</tbody>
</table>

Digital Input Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{IL} input low voltage</td>
<td></td>
<td>0 V</td>
<td>0.8 V</td>
</tr>
<tr>
<td>V_{IH} input high voltage</td>
<td></td>
<td>2 V</td>
<td>5.25 V</td>
</tr>
<tr>
<td>I_{IL} input low current (V_{in} = 0 V)</td>
<td></td>
<td>—</td>
<td>−10 μA</td>
</tr>
<tr>
<td>I_{IH} input high current (V_{in} = 5 V)</td>
<td></td>
<td>—</td>
<td>120 μA</td>
</tr>
</tbody>
</table>

Digital Output Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Voltage Level</th>
<th>Current Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{OL}</td>
<td>0.6 V</td>
<td>6 mA</td>
</tr>
<tr>
<td>V_{OH}</td>
<td>2.7 V</td>
<td>−16 mA</td>
</tr>
</tbody>
</table>

1 Stresses beyond those listed under Input voltage protection may cause permanent damage to the device.
General-Purpose Counter/Timers
Number of counter/timers ............... 2
Resolution .................................... 32 bits
Counter measurements ................ Edge counting, pulse, semi-period, period, two-edge separation
Position measurements .................. X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications ..................... Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks .................... 80 MHz, 20 MHz, 0.1 MHz
External base clock frequency ...... 0 MHz to 20 MHz
Base clock accuracy ................... 50 ppm
Inputs ....................................... Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs ............ PFI <0..3>, PFI <8..11>, many internal signals
FIFO ........................................... 1,023 samples
Data transfers .............................. USB Signal Stream, programmed I/O

Frequency Generator
Number of channels ................... 1
Base clocks ................................ 10 MHz, 100 kHz
Divisors ................................... 1 to 16
Base clock accuracy ................... 50 ppm
Output can be available on any PFI <4..7> or PFI <12..15> terminal.

External Digital Triggers
Source .................................... PFI <0..3>, PFI <8..11>
Polarity ................................. Software-selectable for most signals
Analog input function .................. Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase
Analog output function ............... Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer functions ............ Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down

Bus Interface
USB ......................................... USB 2.0 Hi-Speed or full-speed1
USB Signal Stream (USB) .......... 4, can be used for analog input, analog output, counter/timer 0, counter/timer 1

Power Requirements
USB Input voltage on USB-621x
USB port .............................. 4.5 to 5.25 V in configured state
Maximum inrush current .......... 500 mA
No load typical current ........... 320 mA at 4.5 V
Maximum load
Typical current ....................... 400 mA at 4.5 V
Suspencl current ...................... 260 μA, typical
+5V terminal as output
Voltage ............................... 4.6 to 5.2 V
Current (internally limited) ...... 50 mA max, shared with digital outputs

1 If you are using a USB M Series device in full-speed mode, device performance will be lower and you will not be able to achieve maximum sampling/update rates.
+5V terminal as input

Voltage ....................................... 4.75 to 5.35 V
Current........................................ 350 mA max, self-resetting fuse

Caution Do not exceed 16 mA per DIO pin.

Protection .................................... ±10 V

**Maximum Working Voltage**

**USB-6210/6211**
Channel-to-earth ground............. 11 V, Measurement Category I

Caution Do not use for measurements within Categories II, III, or IV.

**USB-6215/6218**
Channel-to-earth ground2
Continuous................................. ≤30 Vrms/60 VDC, Measurement Category I

Withstand ..................................... ≤840 Vrms/1200 VDC, verified by a 5 s dielectric withstand test

Channel-to-bus4
Continuous................................. ≤30 Vrms/60 VDC, Measurement Category I

Withstand ..................................... ≤1400 Vrms/1950 VDC, verified by a 5 s dielectric withstand test

Analog channel to AI GND/AO GND
(in Figure 1, |Va – Vc|) .................. ≤11 V, Measurement Category I

Digital channel to D GND
(in Figure 1, |Vb – Vc|) .................... ≤5.25 V, Measurement Category I

Caution This device is rated for Measurement Category I and the voltage across the isolation barrier is limited to no greater than 30 Vrms/60 VDC/42.4 Vpk continuous. Do not use for measurements within Categories II, III, or IV.

Figure 1 illustrates the maximum working voltage specifications.

**Environmental**

Operating temperature.....................0 to 45 °C

Storage temperature.......................–20 to 70 °C

Humidity..........................................10 to 90% RH, noncondensing

Maximum altitude ...........................2,000 m

Pollution Degree
(indoor use only) .............................2

---

1 Maximum working voltage refers to the signal voltage plus the common-mode voltage.
2 In Figure 1, |Va – Vd|, |Vb – Vd|, and |Vc – Vd|.
3 Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.
4 In Figure 1, |Va – Ve|, |Vb – Ve|, and |Vc – Ve|.
Physical Characteristics

Enclosure dimensions (includes connectors) .......................... 16.9 × 9.4 × 3.1 cm (6.65 × 3.70 × 1.20 in.)
Weight USB-6210/6211/6215/6218 .......................... 205 g (7.23 oz)

I/O connectors
- USB-6210/6211/6215 ................... Two 16-position combicon
- USB-6218 ................................. Four 16-position combicon
- USB connector .......................... Series B receptacle

Screw terminal wiring .......................... 16 to 28 AWG
Torque for screw terminals .................. 0.22–0.25 N · m (2.0–2.2 lb · in.)

Safety
This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:
- IEC 61010-1, EN-61010-1
- UL 61010-1, CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label or visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility
This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:
- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance
This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:
- 73/23/EEC; Low-Voltage Directive (safety)
- 89/336/EEC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of their life cycle, all products must be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit ni.com/environment/weee.htm.
Figure 2. USB-6210 Pinout

Figure 3. USB-6211/6215 Pinout

NC = No Connect
Figure 4. USB-6218 Pinout