USB-3100 Series
USB Voltage and Current Output Devices

Features
• 4, 8, or 16 analog outputs
• 16-bit resolution
• Update rates from 100 S/s to 100 kS/s
• 4, 8, or 16 analog current outputs available
• High-drive output capability available
• Digital I/O, counter/timer available
• Synchronous update available

Software
• TracerDAQ® software included for acquiring and displaying data and generating signals
• Universal Library includes support for Visual Studio® and Visual Studio® .NET, including examples for Visual C++®, Visual C#®, Visual Basic®, and Visual Basic® .NET
• Comprehensive drivers for DASYLab® and NI LabVIEW™
• Supported by MATLAB® Data Acquisition Toolbox™
• InstaCal software utility for installing, calibrating, and testing
• Supported Operating Systems: Windows 7/Vista/XP SP2, 32- or 64-bit

Overview
USB-3100 Series are voltage and current output USB 2.0 full-speed devices. Each device provides four, eight, or 16 voltage outputs. The USB-3102/3104/3106 also provide four, eight, or 16 current outputs. All devices provide synchronous and concurrent voltage updates.

All USB-3100 Series devices except the USB-3101FS provide eight digital I/O lines and one 32-bit event counter.

The USB-3110/3112/3114 are powered by an external AC adapter. All other devices in the Series are powered by the +5 V USB supply from the computer.

The USB-3101FS has 250 Vrms channel-to-ground isolation that protects the device and computer from ground spikes and ensures a reliable data stream, making it suitable for high-voltage applications.

Analog Output
All USB-3100 Series devices provide either four, eight, or 16 channels of 16-bit analog output.

USB-3101FS: Each channel has a fixed ±10 V voltage output range. Channel outputs can be updated individually or simultaneously. Each channel has a D/A converter (DAC) that produces a voltage signal. Each channel also has ±30 V overvoltage and indefinite short-circuit protection.

For high-voltage applications, use the USB-3101FS with the ACC-107 backshell accessory to ensure that the terminals are not accessible. The backshell also provides strain relief to protect the screw terminals.

USB-3100 Series Selection Chart

<table>
<thead>
<tr>
<th>Model</th>
<th>Voltage Output</th>
<th>Update Rate</th>
<th>Current Output</th>
<th>DIO</th>
<th>Counter/Timer</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB-3101</td>
<td>4</td>
<td>100 S/s</td>
<td>—</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3102</td>
<td>4</td>
<td>100 S/s</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3103</td>
<td>8</td>
<td>100 S/s</td>
<td>—</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3104</td>
<td>8</td>
<td>100 S/s</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3105</td>
<td>16</td>
<td>100 S/s</td>
<td>—</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3106</td>
<td>16</td>
<td>100 S/s</td>
<td>16</td>
<td>8</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>USB-3110</td>
<td>4 high-drive</td>
<td>100 S/s</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>USB-3112</td>
<td>8 high-drive</td>
<td>100 S/s</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>USB-3114</td>
<td>16 high-drive</td>
<td>100 S/s</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>USB-3101FS</td>
<td>4</td>
<td>100 kS/s</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>250 Vrms channel-to-ground</td>
</tr>
</tbody>
</table>

All Other USB-3100 Series Devices: Each channel is software-selectable for either a bipolar voltage output range of ±10 V or a unipolar range of 0 V to 10 V. Channel outputs can be updated individually or simultaneously.

The USB-3101FS includes four simultaneously-updating analog output channels with 250 Vrms channel-to-ground isolation.
USB-3100 Series
General Information and Specifications

Current Output (USB-3102/3104/3106 Only)
These devices provide 0 mA to 20 mA of current output. Each DAC controls a voltage/current channel pair simultaneously. Each channel pair can be updated individually or simultaneously.

Synchronous DAC Updates
All USB-3100 Series devices except for the USB-3101FS have a synchronous DAC load connection pin (SYNCLD) that simultaneously updates DAC outputs on multiple devices. You can configure this with software as an input (slave mode) or as an output (master mode).

In slave mode, the SYNCLD pin receives the D/A LOAD signal from an external source. When the SYNCLD pin receives the trigger signal, the analog outputs are updated simultaneously.

In master mode, the internal D/A LOAD signal is sent to the SYNCLD pin. You can then synchronize with a second device of the same type and simultaneously update the DAC outputs on each device.

On power up and reset, the SYNCLD pin is set to slave mode (input).

Digital I/O
All USB-3100 Series devices except for the USB-3101FS have eight bidirectional digital I/O connections. The DIO lines can be independently programmed for input or output. All digital pins are floating by default. A screw terminal connection is provided to configure for pull-up (+5 V) or pull-down (0 V).

Counter Input
Each USB-3100 Series device except for the USB-3101FS has a 32-bit event counter for counting TTL pulses. The counter increments when the TTL levels transition from low to high. The counter accepts frequency inputs of up to 1 MHz.

Specifications
All USB-3100 Series Devices Except for the USB-3101FS

General
Environment
Operating Temperature
USB-3101/3103/3105: 0 °C to 70 °C
All Other Devices: 0 °C to 50 °C
Storage Temperature: -40 °C to 85 °C
Relative Humidity (RH): 0% to 90% RH, noncondensing
Communications: USB 2.0 full-speed mode (12 Mbps)
Signal I/O Connector: Screw terminals
Power
Supply Current (USB Enumeration): <100 mA
Supply Current (Quiescent): Total quiescent current requirement 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 VOUTx outputs.
USB-3101/3102: 140 mA typ
USB-3103/3104/3110: 160 mA typ
USB-3105/3106: 200 mA typ
USB-3112: 225 mA max
USB-3114: 355 mA max
+5 V User Output Voltage Range: 4.5 V to 5.25 V (assumes USB power supply is within specified limits)
+5 V User Output Current: 10 mA max (refers to the total amount of current that can be sourced from the +5 V user terminal for general use; also includes any additional contribution due to DIO loading)
USB-3102/3104/3106
ITEST Output Voltage Range: 13 V, ±16% typ
ITEST Output Current: 30 mA max
Refers to the total maximum amount of current that can be sourced from the ITEST user terminal, which should only be used for biasing individual IOUTx outputs to facilitate functional testing. Place a load resistor of 100 Ω between the ITEST pin and the IOUTx pin for proper operation
USB-3101/3102/3104/3110/3112/3114 Only
Output Voltage: 5 V, ±5%
Output Wattage: 10 W
Power Jack Configuration: Two conductor
Power Jack Barrel Diameter: 6.3 mm
Power Jack Pin Diameter: 2.0 mm
Power Jack Polarity: Center positive
Dimensions (L × W × H): 127.0 × 88.9 × 35.6 mm (5.0 × 3.5 x 1.4 in.)

Analog Output
D/A Converter: DAC8554
Number of Channels
USB-3101/3102/3110: 4
USB-3103/3104/3112: 8
USB-3105/3106/3114: 16
On the USB-3102/3104/3106, each DAC8554 output controls a voltage and current output channel-pair simultaneously. For example, writing to voltage output channel 0 also updates current output channel 0; conversely, writing to current output channel 0 also updates voltage output channel 0. Disconnect unused voltage and current output channels.
Resolution: 16 bits

Output Ranges (Software-Selectable)
Calibrated: ±10 V, 0 V to 10 V
Uncalibrated: ±10.2 V, -0.04 V to 10.08 V
Output Transient
±10 V to 0 V (0 V to 10 V) or (0 V to 10 V) to ±10 V
Range Selection: The output voltage level defaults to 0 V when the output voltage range is reconfigured. If the host computer is reset, shut down, or suspended, or a reset command is issued to the device.
Duration: 5 µs typ
Amplitude: 5 V p-p typ
Host Trigger is Reset, Powered On, Suspended, or a Reset Command is Issued to Device
The duration of this output transient is depends highly on the enumeration process of the host computer. Typically, the output is stable after two seconds.
Duration: 2 s typ
Amplitude: 5 V peak typ

Differential Nonlinearity: The maximum differential nonlinearity specification applies to the entire operating temperature range. This specification also accounts for the maximum errors due to the software calibration algorithm (in Calibrated mode only) and the DAC8554 nonlinearity.
Calibrated: ±0.15 LSB typ, ±2 LSB typ
Uncalibrated: ±0.25 LSB typ, ±1 LSB max

Output Current
VOUTx Pins
USB-3101 Through USB-3106: ±3.5 mA typ
USB-3110: ±40 mA max
USB-3112/3114: ±40 mA max single channel, ±180 mA total load current
Output Short-Circuit Protection
VOUTx Connected to AGND
USB-3101 Through USB-3106: Indefinite
USB-3110/3112/3114: ±100 ms max
Do not keep voltage outputs in a short-circuit condition for longer than the specified limit of 100 ms. For applications that may exceed the 40 mA maximum current limit or the 100 ms short-circuit condition, use external current limiting to prevent potential damage to the device.
Output Coupling: DC
Power On and Reset State
DACs Cleared to Zero-Source: 0 V, ±50 mV typ
Output Range: 0 V to 10 V
Output Noise
0 V to 10 V Range: 14.95 µVrms typ
±10 V Range: 31.67 µVrms typ
Settling Time
To 1 LSB Accuracy: 25 µs typ
Slew Rate
USB-3101 Through USB-3106: 0 V to 10 V Range: 1.20 V/µs typ
±10 V Range: 1.20 V/µs typ
USB-3110/3112/3114
0 V to 10 V Range: 2.0 V/µs typ
±10 V Range: 4.0 V/µs typ
Throughput
Single-Channel: 100 S/s max, system-dependent
Multichannel: 100 S/s/ch max, system-dependent
USB-3100 Series Specifications

USB-3106 Block Diagram

With 16 channels of analog voltage/current output, the USB-3106 contains a superset of the analog output features of these USB-3100 Series devices:
- The USB-3101 provides four channels of analog voltage output
- The USB-3102 provides four channels of analog voltage/current output
- The USB-3103 provides eight channels of analog voltage output
- The USB-3104 provides eight channels of analog voltage/current output
- The USB-3105 provides 16 channels of analog voltage output

Analog Current Output (USB-3102/3104/3106)

Number of Channels
- USB-3102: 4
- USB-3104: 8
- USB-3106: 16

Each DAC8554 output controls a voltage and current output channel-pair simultaneously. For example, writing to voltage output channel 0 also updates current output channel 0; conversely, writing to current output channel 0 also updates voltage output channel 0. Disconnect unused voltage and current output channels.

Absolute Accuracy Components – Calibrated Output

<table>
<thead>
<tr>
<th>Range</th>
<th>% of Reading</th>
<th>Offset</th>
<th>Temperature Drift (%/°C)</th>
<th>Absolute Accuracy at FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10 V</td>
<td>±0.0183</td>
<td>±1.831 mV</td>
<td>0.00055</td>
<td>±3.661 mV</td>
</tr>
<tr>
<td>0 V to 10 V</td>
<td>±0.0183</td>
<td>±0.915 mV</td>
<td>0.00055</td>
<td>±2.746 mV</td>
</tr>
</tbody>
</table>

Resolution: 16 bits
Output Ranges
- Calibrated: 0 mA to 20 mA typ
- Uncalibrated: 0 mA to 25 mA typ

Compliance Voltage Range
- Calibrated Output: 8 V to 36 V

The following formulas calculate the maximum load resistance for correct current output circuit operation. The compliance voltage applied should not exceed the compliance voltage range limits.

Calibrated output

\[
\text{Load Resistance} = \frac{(\text{compliance voltage} - 6 \text{ V})}{0.020 \text{ A}}
\]

Uncalibrated output

\[
\text{Load resistance} = \frac{(\text{compliance voltage} - 6 \text{ V})}{0.025 \text{ A}}
\]

Differential Nonlinearity
- Calibrated: ±1.25 LSB typ, ~2 LSB to 1 LSB max
- Uncalibrated: ±0.25 LSB typ, ~1 LSB to 1 LSB max

The maximum differential nonlinearity specification applies to the entire operating temperature range. This specification also accounts for the maximum errors due to the software calibration algorithm (in calibrated mode only) and the DAC8554 nonlinearities.
USB-3114 Block Diagram

With 16 channels of high-drive analog voltage output, the USB-3114 contains a superset of the analog output features of these USB-3100 Series devices:

° The USB-3110 provides four channels of analog voltage output
° The USB-3112 provides eight channels of analog voltage output

**Absolute Accuracy:** ±0.05% of full-scale range (compliance voltage = 13 V, load resistance = 100 Ω)

**IOUTx Leakage Current:** 100 nA typ for each individual IOUT channel (all zeros written to IOUTx channel)

**Settling Time:** 25 µS typ (full scale step to 1 LSB accuracy; compliance voltage = 12 V, load resistance = 500 Ω)

**Throughput**
- **Single-Channel:** 100 Hz max, system-dependent
- **Multichannel:** 100 Hz/#ch max, system-dependent

**Analog Output Calibration**

**Recommended Warm-Up Time:** 15 minutes min

- **Onboard Precision Reference**
  - DC Level: 5.000 V ±1 mV max.
  - Tempco: ±10 ppm/°C max.
  - Long-Term Stability: ±10 ppm/SQRT(1000 hrs)

**Calibration Method**
- USB-3101 Through USB-3106: Software calibration
- USB-3110/3112/3114: Software calibration (Voutx = 20 mA fixed resistive load)

**Calibration Interval:** 1 year

**Digital I/O**

- **Digital Logic Type:** CMOS
- **Number of I/O:** 8

**Pull-Up/Pull-Down Configuration:**
- **Software-selectable:** all pins floating (default)
- **For pull-down, connect the DIO CTL pin to a DGND pin.**
- **For pull-up, connect the DIO CTL pin to the +5 V pin.**

**Digital I/O Input Loading**
- **TTL (default); 47 KΩ (pull-up/pull down configurations)**

**Digital I/O Transfer Rate (System-Paced):** System-dependent, 33 to 1000 port reads/writes per second.

**Input High Voltage:** 2.0 V min, 5.5 V absolute max
**Input Low Voltage:** 0.8 V max, -0.5 V absolute min

**Output High Voltage (IOH = –2.5 mA):** 3.8 V min, 3.8 V max
**Output Low Voltage (IOL = 2.5 mA):** 0.7 V max

**Power On and Reset State:** Input

**Synchronous DAC Load**

- **Pin Name:** SYNCLD (terminal block pin 49)
- **Power On and Reset State:** Input
- **Pin Type:** Bidirectional
- **Termination:** Internal 100 K pull-down

**Software-Selectable Direction**
- **Output:** Outputs internal D/A LOAD signal
- **Input:** Receiver D/A LOAD signal from external source

**Input Clock Rate:** 100 Hz max
**Clock Pulse Width**
- **Input:** 1 µs min
- **Output:** 5 µs min

**Input Leakage Current:** ±1.0 µA typ
**Input High Voltage:** 4.0 V min, 5.5 V absolute max
**Input Low Voltage:** 1.0 V max, -0.5 V absolute min
**Output High Voltage:** IOH = –2.5 mA; 3.3 V min
**No Load:** 3.8 V min

SYNCLD is a Schmitt trigger input and is over-current protected with a 200 Ω series resistor.
### USB-3100 Series

#### Specifications

### USB-3101FS Block Diagram

- **Isolated DAC**: Overvoltage Short-circuit Protection
- **Overvoltage Short-circuit Protection**: Indefinitely
- **Update Rate**: 100 kS/s per channel max
- **Noise**: 260 µVrms
- **Settling Time**: 100 µF Load to 1 LSB
- **Glitch Energy**: 256 Steps, Worst Case: 2 mV for 2 µs
- **Capacitive Drive**: 1,500 pF min
- **Differential Nonlinearity**: –1 to 2 LSBs max
- **Integral Nonlinearity (Endpoint)**: 16 LSBs max

### Output Low Voltage

- **IOL = 2.5 mA**: 1.1 V max
- **No Load**: 0.6 V max

When SYNCLD is in input mode, the analog outputs may either be updated immediately or when a positive edge is seen on the SYNCLD pin (this is under software control). However, the pin must be at a low logic level in order for the DAC outputs to be updated immediately. If an external source is pulling the pin high, no update occurs.

### Counter

- **Pin Name**: CTR
- **Number of Channels**: 1
- **Resolution**: 32-bits
- **Counter Type**: Event counter
- **Input Type**: TTL, rising edge triggered
- **Counter Read/Write Rates (Software-Paced)**
  - **Counter Read**: System-dependent, 33 to 1000 reads per second
  - **Counter Write**: System-dependent, 33 to 1000 reads per second
- **Schmidt Trigger Hysteresis**: 20 mV to 100 mV
- **Input Leakage Current**: ±1.0 µA typ
- **Input Frequency**: 1 MHz max
- **High Pulse Width**: 500 ns min
- **Low Pulse Width**: 500 ns min
- **Input Voltage**: 4.0 V min, 5.5 V absolute max
- **Input Low Voltage**: 1.0 V max, –0.5 V absolute min

### Memory

- **EEPROM**: 256 bytes
- **EEPROM Configuration**
  - **Address Range**: 0x000-0x0FF
  - **Access**: Read/write
  - **Description**: 256 bytes user data

### Microcontroller

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

### Specifications USB-3101FS

#### General

- **Environment**
  - **Operating Temperature**: –40 °C to 70 °C
  - **Storage Temperature**: –40 °C to 85 °C
  - **Relative Humidity (RH)**:
    - **Operating Humidity**: 10% to 90% RH non-condensing
    - **Storage Humidity**: 5% to 95% RH non-condensing
- **Communications**: USB 2.0 high-speed (480 Mbps)

- **Power**
  - **Power Consumption**: 625 mW max
  - **Thermal Dissipation at 70 °C**: 625 mW max
  - **Dimensions (L x W x H)**: 114.3 x 139.7 x 38.1 mm
  - **Weight**: 544 g (1.2 lb)

### Analog Voltage Output

- **Number of Channels**: 4
- **D/A Converter Resolution**: 16 bit
- **D/A Converter Type**: String
- **Output Range**: ±10 V
- **Power On Voltage**: 0 V

### Accuracy

<table>
<thead>
<tr>
<th>Measurement Conditions</th>
<th>% of Reading</th>
<th>% of Range (Range is Equal to ±10.7 V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrated, max (–40 to 70 °C)</td>
<td>0.35%</td>
<td>0.75%</td>
</tr>
<tr>
<td>Calibrated, typ (25 °C, ±5 °C)</td>
<td>0.01%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Uncalibrated, max (–40 to 70 °C)</td>
<td>2.2%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Uncalibrated, typ (25 °C, ±5 °C)</td>
<td>0.3%</td>
<td>0.25%</td>
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- **High Pulse Width**: 500 ns min
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<td>0.35%</td>
<td>0.75%</td>
</tr>
<tr>
<td>Calibrated, typ (25 °C, ±5 °C)</td>
<td>0.01%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Uncalibrated, max (–40 to 70 °C)</td>
<td>2.2%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Uncalibrated, typ (25 °C, ±5 °C)</td>
<td>0.3%</td>
<td>0.25%</td>
</tr>
</tbody>
</table>
## USB-3100 Series
### Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB-based four-channel, 16-bit, 100 kS/s, simultaneously updating analog output device with USB cable</td>
<td>USB-3101FS</td>
</tr>
<tr>
<td>USB-based four-channel, 16-bit, analog voltage output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3101</td>
</tr>
<tr>
<td>USB-based four-channel, 16-bit, analog voltage/current output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3102</td>
</tr>
<tr>
<td>USB-based eight-channel, 16-bit analog voltage output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3103</td>
</tr>
<tr>
<td>USB-based eight-channel, 16-bit analog voltage/current output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3104</td>
</tr>
<tr>
<td>USB-based 16-channel, 16-bit voltage output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3105</td>
</tr>
<tr>
<td>USB-based 16-channel, 16-bit voltage/current output device with one 32-bit counter, eight DIO lines, and USB cable</td>
<td>USB-3106</td>
</tr>
<tr>
<td>USB-based four-channel, 16-bit high-drive analog output device with one 32-bit counter, eight DIO lines, USB cable, and PS-5V2AEPS power supply</td>
<td>USB-3110</td>
</tr>
<tr>
<td>USB-based eight-channel, 16-bit high-drive analog output device with one 32-bit counter, eight DIO lines, USB cable, and PS-5V2AEPS power supply</td>
<td>USB-3112</td>
</tr>
<tr>
<td>USB-based 16-channel, 16-bit high-drive analog output device with one 32-bit counter, eight DIO lines, USB cable, and PS-5V2AEPS power supply</td>
<td>USB-3114</td>
</tr>
</tbody>
</table>

**Accessories & Cables**

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB-3101FS Backshell with 10-position connector block (quantity 1)</td>
<td>ACC-107</td>
</tr>
<tr>
<td>10-position detachable screw terminal connector blocks (quantity 10)</td>
<td>ACC-121</td>
</tr>
</tbody>
</table>

**Software**

<table>
<thead>
<tr>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icon-based data acquisition, graphics, control, and analysis software</td>
<td>DASYLab</td>
</tr>
<tr>
<td>Out-of-the-box virtual instrument suite with strip chart, oscilloscope, function generator, and rate generator</td>
<td>TracerDAQ Pro</td>
</tr>
</tbody>
</table>