What does 12- or 16-bit resolution mean?

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What is resolution?

Resolution in this context refers to the conversion of an analog voltage to a digital value in a computer (and vice versa). A computer is a digital machine and thus stores a number as a series of ones and zeroes. If you are storing a digital 2-bit number you can store 4 different values: 00, 01, 10, or 11. Now, say you have a device which converts an analog voltage between 0 and 10 volts into a 2-bit digital value for storage in a computer. This device will give digital values as follows:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>2-Bit Digital Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2.5</td>
<td>00</td>
</tr>
<tr>
<td>2.5 to 5</td>
<td>01</td>
</tr>
<tr>
<td>5 to 7.5</td>
<td>10</td>
</tr>
<tr>
<td>7.5 to 10</td>
<td>11</td>
</tr>
</tbody>
</table>

So in this example, the 2-bit digital value can represent 4 different numbers, and the voltage input range of 0 to 10 volts is divided into 4 pieces giving a voltage resolution of 2.5 volts per bit. A 3-bit digital value can represent 8 \((2^3)\) different numbers. A 12-bit digital value can represent 4096 \((2^{12})\) different numbers. A 16-bit digital value can represent 65536 \((2^{16})\) different numbers. It might occur to you at this point that a digital input could be thought of as a 1-bit analog to digital converter. Low voltages give a 0 and high voltages give a 1.

In the case of the LabJack U12, a single-ended analog input has a voltage range of -10 volts to +10 volts (20 volt total span) and returns a 12-bit value. This gives a voltage resolution of 20/4096 or 0.00488 volts per bit (4.88 mV/bit).

What does it mean to say a device is 12-bit, 16-bit, or 24-bit?

When you see analog input DAQ devices from various manufacturers called 12-bit, 16-bit, or 24-bit, it generally just means they have an ADC (analog to digital converter) that returns that many bits. When an ADC chip returns 16 bits, it is probably better than a 12-bit converter, but not always. The simple fact that a converter returns 16-bits says little about the quality of those bits.
It is hard to simply state "the resolution" of a given device. What we like to do, is provide actual measured data that tells you the resolution of a device including typical inherent noise.

If you look at a device called "24-bit" just because it has a converter that returns 24-bits of data per sample, you will find that it typically provides 20 bits effective or 18 bits noise-free (like the UE9-Pro). The U6-Pro and T7-Pro provide some of the best performance around from a 24-bit ADC, and they do about 22 bits effective or 20 bits noise-free. You will see with these devices we might mention they have a 24-bit ADC (as that is what people look and search for), but we try not to call them "24-bit" and try to stick with the effective resolution.

Another interesting thing about your typical 24-bit sigma-delta converter, is that you can look at them as only having a 1-bit ADC inside, but with timing and math they can produce 24-bit readings:

http://www.maxim-ic.com/appnotes.cfm/appnote_number/1870/

**Hardware with a 24-bit ADC**

- **U6-Pro**: 22-bit Effective Res
- **T7-Pro**: 22-bit Effective Res
- **UE9-Pro**: 20-bit Effective Res

**Hardware with a 16-bit ADC or less**

- **U6**: 19-bit Effective Res
- **T4**: 12-bit Effective Res
- **T7**: 19-bit Effective Res
- **UE9**: 16-bit Effective Res
- **U3**: 12-bit Effective Res
- **U12**: 12-bit Effective Res