A few words about oscilloscope resolution

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Solution: Resolution for a measurement system is the smallest change that can be observed.

We can calculate the resolution very easily:

Measurement Resolution = Measurement Range/Bits

An instrument having 12-bit measurement resolution on a 10V range will have a minimum resolution of $10V/2^{12} = 0.002mV$.

The important thing to consider here is the ***total*** range of the measurement.

For example, an oscilloscope that has 8 vertical divisions and has the vertical scale set to 2V/div has a ***displayed*** range of 16V (8 div * 2V/div = 16V).

If the scope has 8-bits of resolution, you may expect that the resolution is going to be 0.063V ($16V/2^8 = 0.063V$).

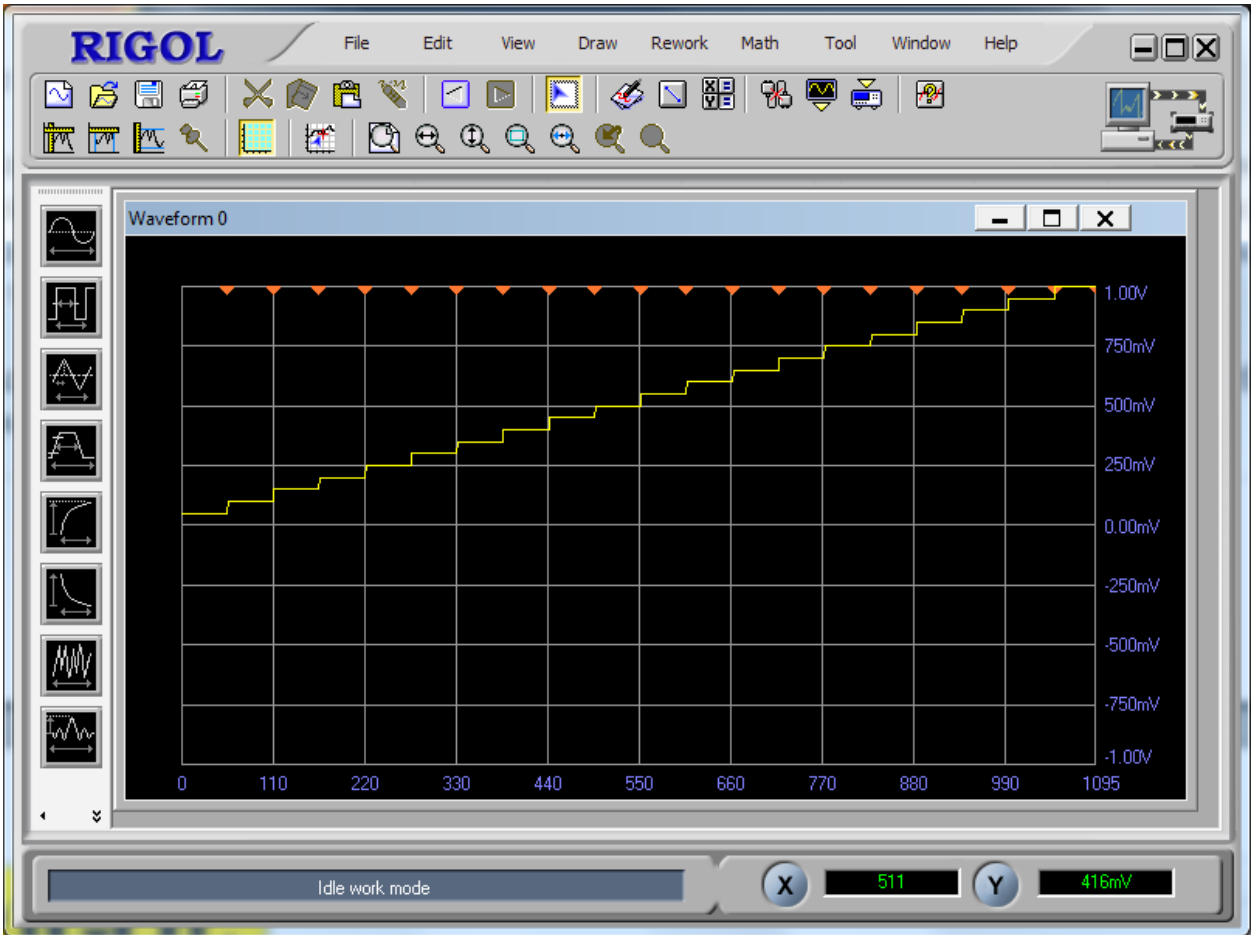
But, if you look at the raw data file from a scope and took a look at the voltage delta between neighboring points, you would likely find the resolution to be 0.08V... not the expected 0.063V.

What is going on here?

With an oscilloscope, the total range may not just be the displayed data. The actual range may be slightly above and below the displayed data. Put another way, the displayed data window is a subset of the total range. The actual range depends a number of factors, including: the display resolution, number of pixels, and scope design, but it should be close.

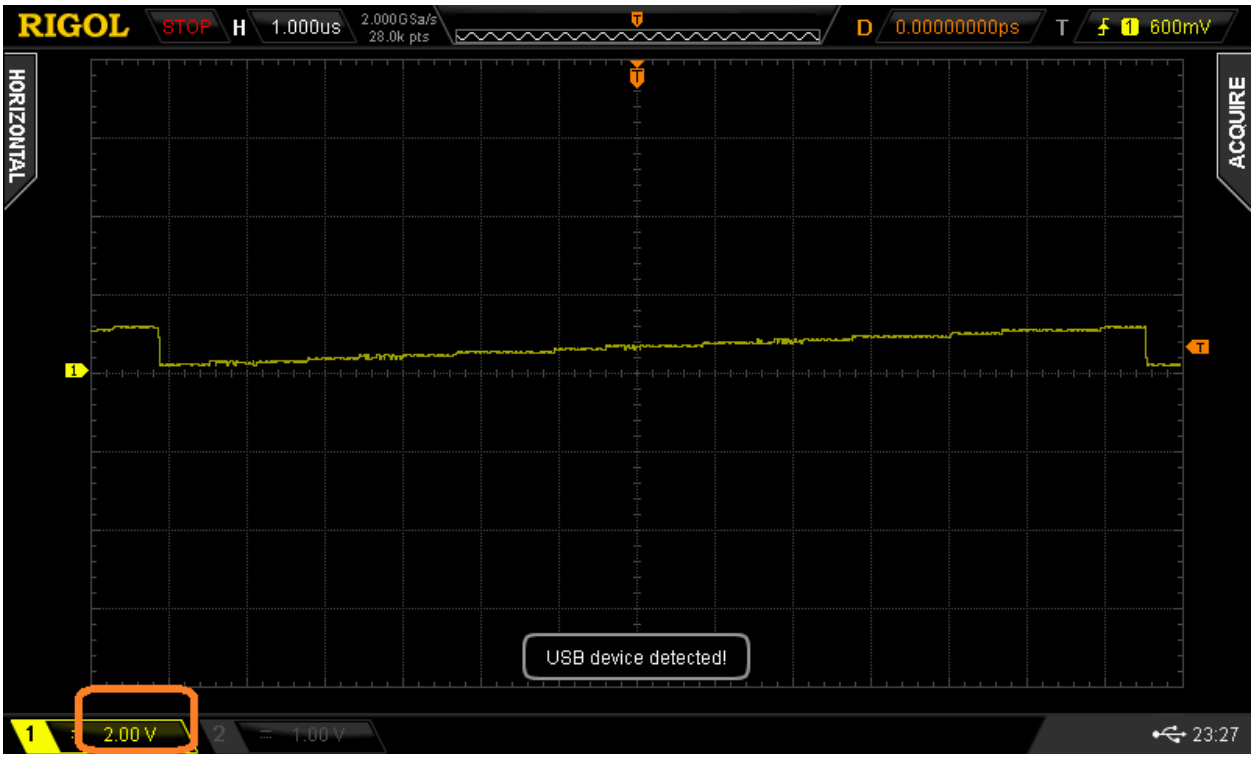
For demonstration, lets produce an arbitrary waveform with step sizes a bit smaller than the resolution we expect.

Here is the output waveform of an arbitrary waveform generator set to deliver 20 50mV steps from 0V to 1V.



Below is a screen shot of a DS2000 Oscilloscope with Channel 1 connected to the source. Again, it is stepping in 50mv steps from 0V to 1V.

The scope is in the factory default configuration with 8-bit resolution and 8 vertical divisions. Horizontal scal is set to 1us/div.



On the 2V/Div range, the ***displayed*** dynamic range is 16V.

The step size of the signal is 50mV. But, when we look at the CSV data file from the scope, we see that the smallest difference between points (delta V) is 80mV.

The reason is that the total range is not 16V, as we expected. It is actually more like 20V. There are valid readings above and below the displayed values.

If we calculate the step size for a 20V total range, we get 78mV (20V / 2^8). Very close to the delta when measuring the 50mV step signal.

If we try a similar experiment on a scope with a larger display (more vertical pixels) such as the Rigol DS4000, we see that the minimum step size is approximately 62mV. Therefore the displayed range is much closer to the total measurement range. This is primarily due to the larger display. There are more pixels available to present a pixel-per-bit image.

In conclusion, the displayed range of an oscilloscope may not represent the actual measurement range. This is mainly an artifact of displays that have less vertical pixels than the AD converter has bits. Displays with less vertical pixels will often have measurement areas outside of the displayed values.

Choosing an appropriate vertical range is essential to achieving the highest degree of resolution from your scope.

Headquarters

RIGOL TECHNOLOGIES, INC.
No.156,Cai He Village,
Sha He Town,
Chang Ping District, Beijing,
102206 P.R.China
Tel:+86-10-80706688
Fax:+86-10-80705070
Email: support@rigol.com

USA

RIGOL TECHNOLOGIES,USA INC.
7401 First Place, Suite N
Oakwood Village
OH 44164, USA
Toll free: 877-4-RIGOL-1
Office: (440) 232-4488
Fax: (216)-754-8107
Email: info@rigol.com

EUROPE

RIGOL TECHNOLOGIES GmbH
Lindbergh str. 4
82178 Puchheim
Germany
Tel: 0049- 89/89418950
Email: info-europe@rigoltech.com