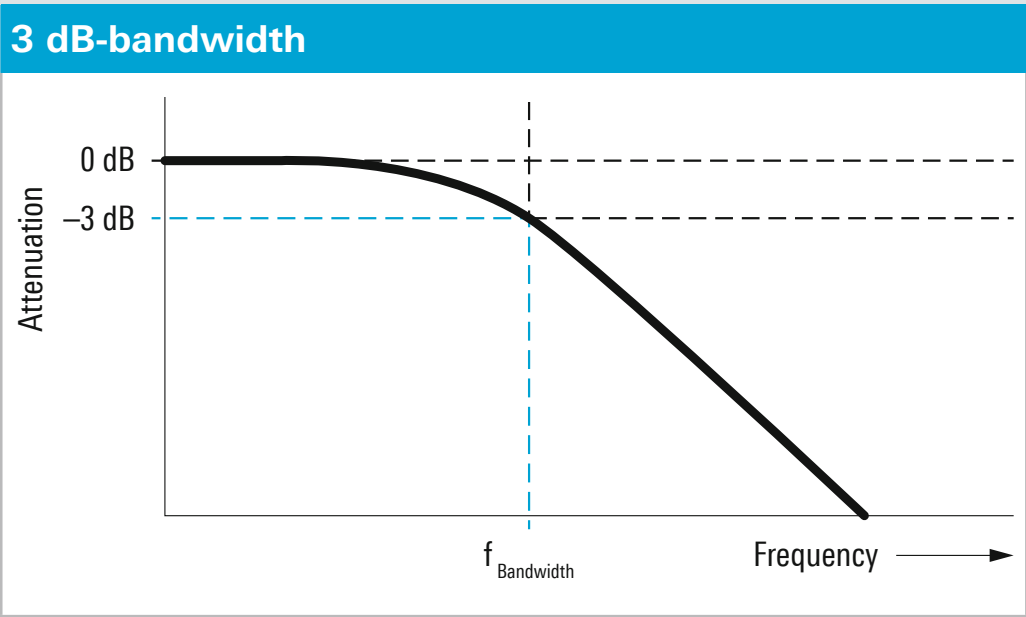


Oscilloscope fundamentals

Bandwidth

Bandwidth is the most important oscilloscope attribute.

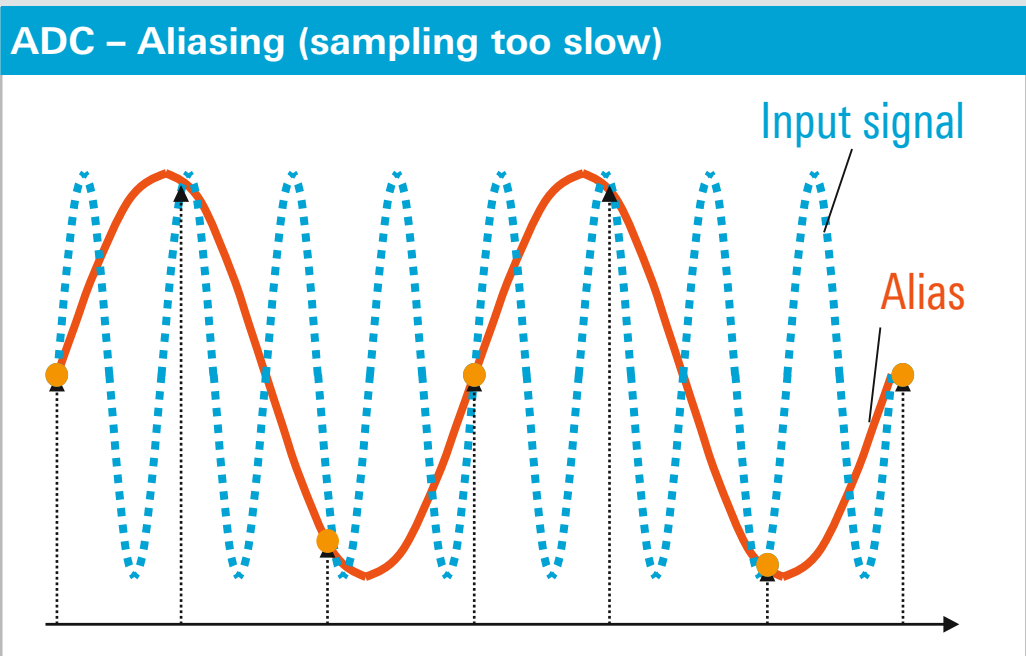
- Oscilloscopes can only accurately measure signals with frequencies less than the rated oscilloscope bandwidth; input signals greater than the oscilloscope bandwidth will not be captured and displayed
- The bandwidth of an oscilloscope is the frequency at which an input signal is attenuated by 3 dB; at this frequency, a sine wave will have a displayed amplitude of 70.7% of the real signal amplitude
- To correctly measure digital signals, the oscilloscope's bandwidth should be at least 5 times the signal frequency to capture the fundamental frequency plus the 3rd and 5th harmonic



Sampling rate

An oscilloscope's sampling rate is the number of samples/s that the instrument can acquire.

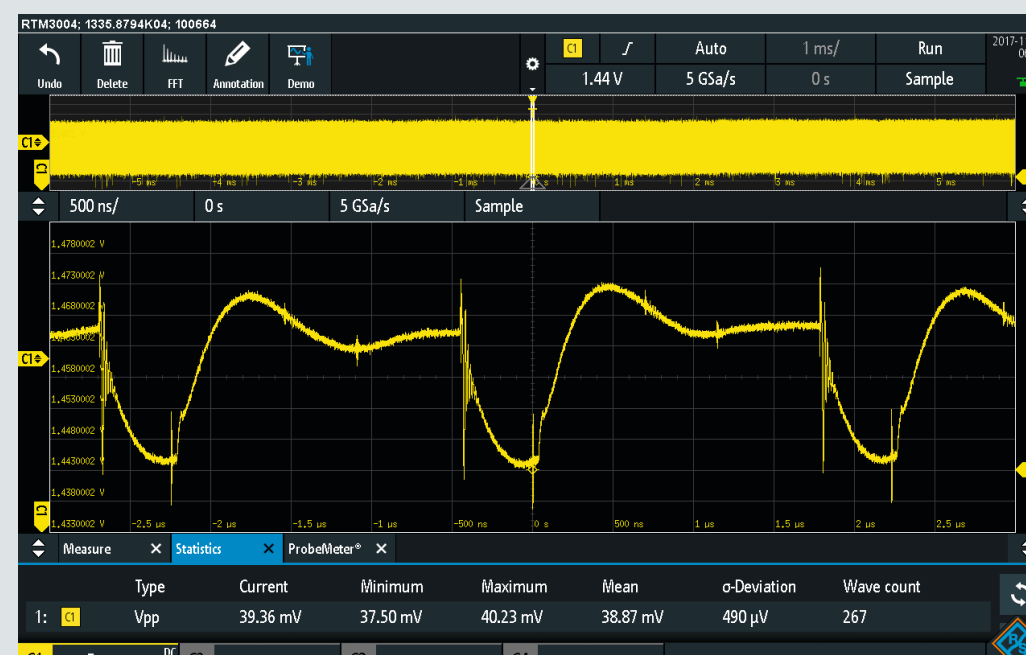
- The oscilloscope's ADC (analog to digital converter) determines the sampling rate
- To accurately reconstruct signals, the sampling rate needs to be at least twice the signal frequency; most scopes have a maximum sampling rate of 2.5 times the oscilloscope's rated bandwidth
- Aliasing occurs when the sampling rate is too slow



Memory depth

Memory depth is the number of ADC samples stored per acquisition.

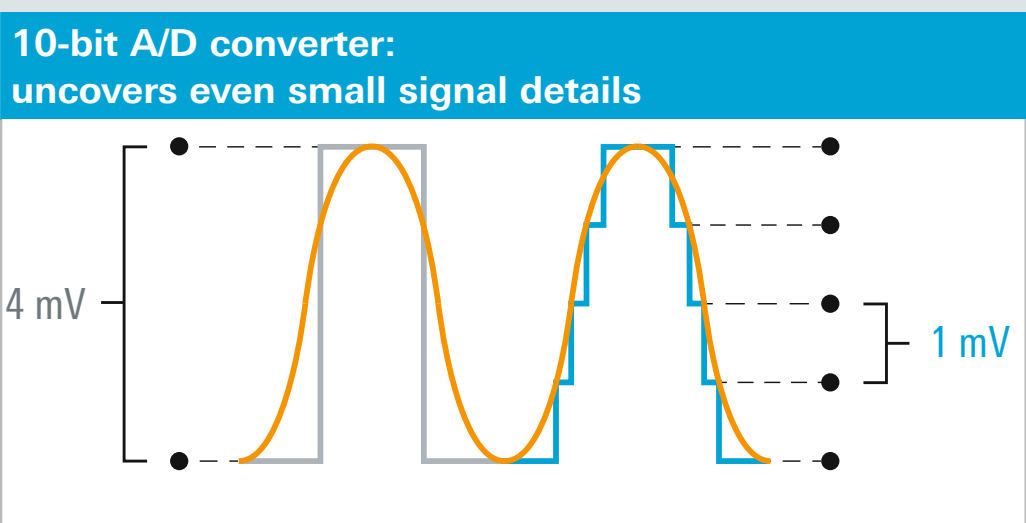
- Captured time = $\frac{\text{memory depth}}{\text{sampling rate}}$
- The more memory depth, the more time can be captured in an acquisition
- When sampling at the fastest rate and using all memory, the oscilloscope is forced to reduce the sampling rate when you acquire more time
- More memory is always better, but it can require additional processing time and slow down the acquisition rate



Vertical resolution

The vertical resolution of an oscilloscope is determined by the oscilloscope's ADC.

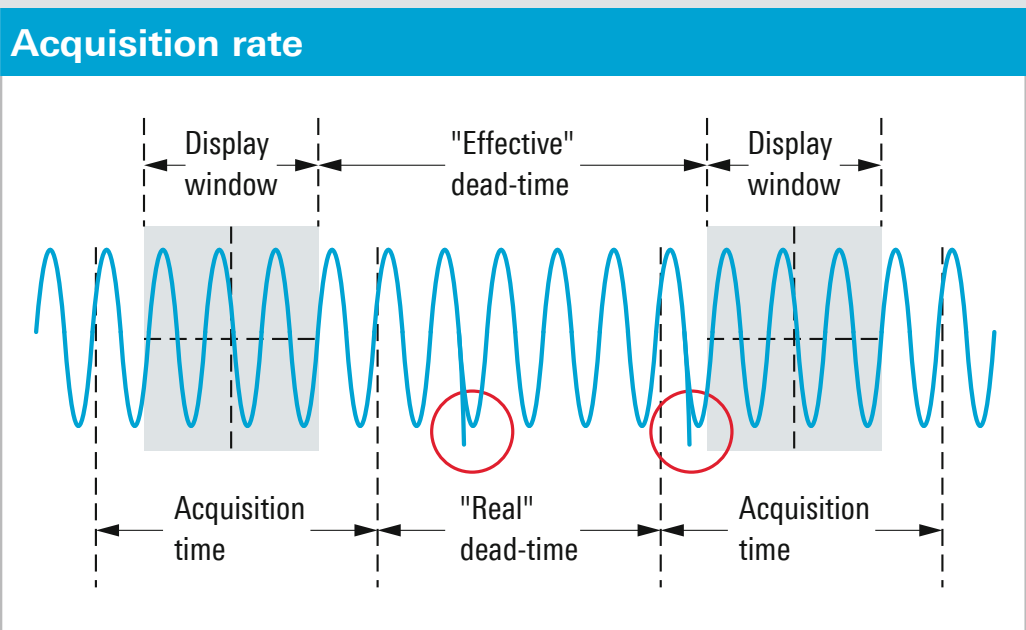
- An 8-bit ADC can place an input signal into any of 256 (28) vertical levels, while a 10-bit ADC has 1024 (210) vertical levels
- Oscilloscope noise produces vertical values that deviate from the actual signal values by the amount of inherent noise
- For repetitive signals, averaging of acquisitions reduces noise
- The high resolution mode averages adjacent signals and can be used on all signals



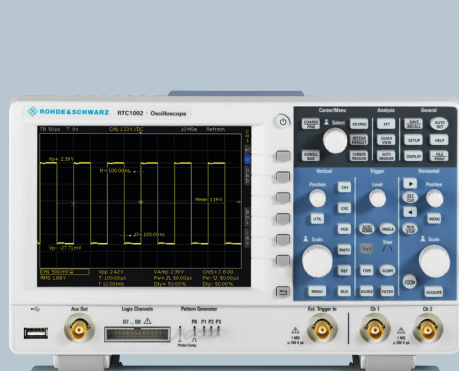
Acquisition rate

The acquisition rate is the number of times/s the oscilloscope can capture and display waveforms.

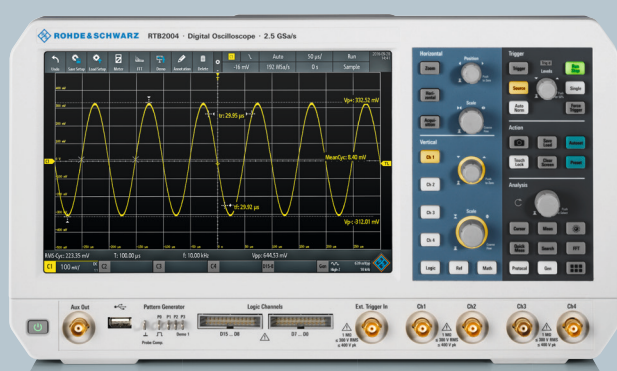
- Oscilloscopes with faster acquisition rates have less dead time between acquisitions
- Oscilloscopes with faster acquisition rates feel more responsive when you turn knobs or push buttons
- Acquisition rate slows down as the acquisition memory depth is increased, due to additional processing time
- Acquisition rate slows down when measurements and math are enabled



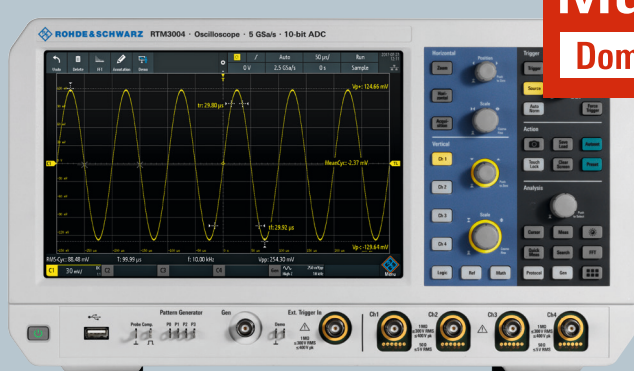
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