# 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

3 dB-bandwidth

0 dB / −3 dB / Attenuation / $f_{Bandwidth}$ / Frequency
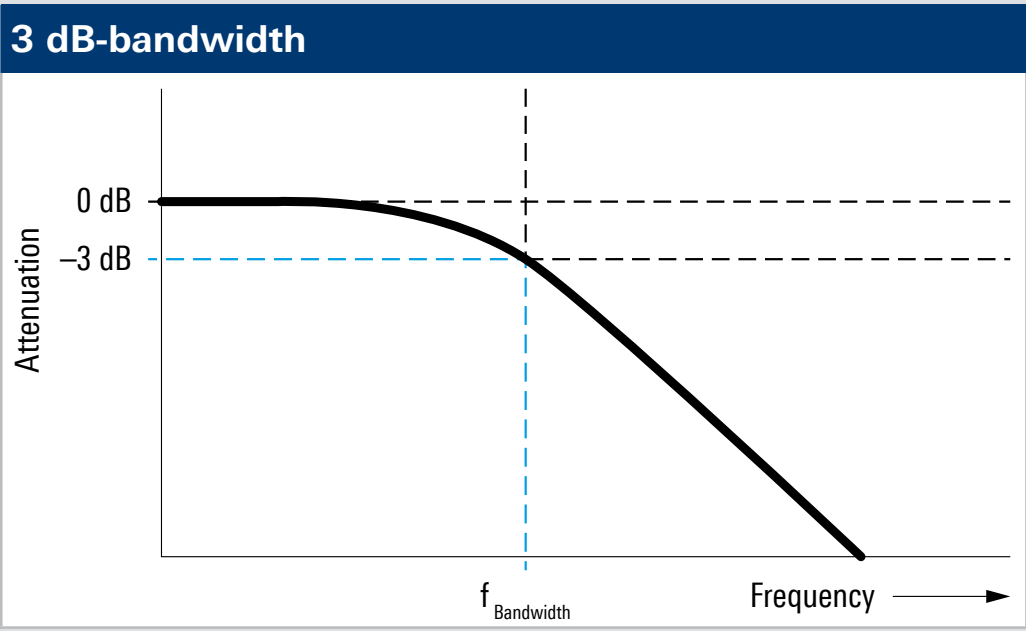
SAMPLING RATE

**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

ADC – Aliasing (sampling too slow)

Input signal / Alias
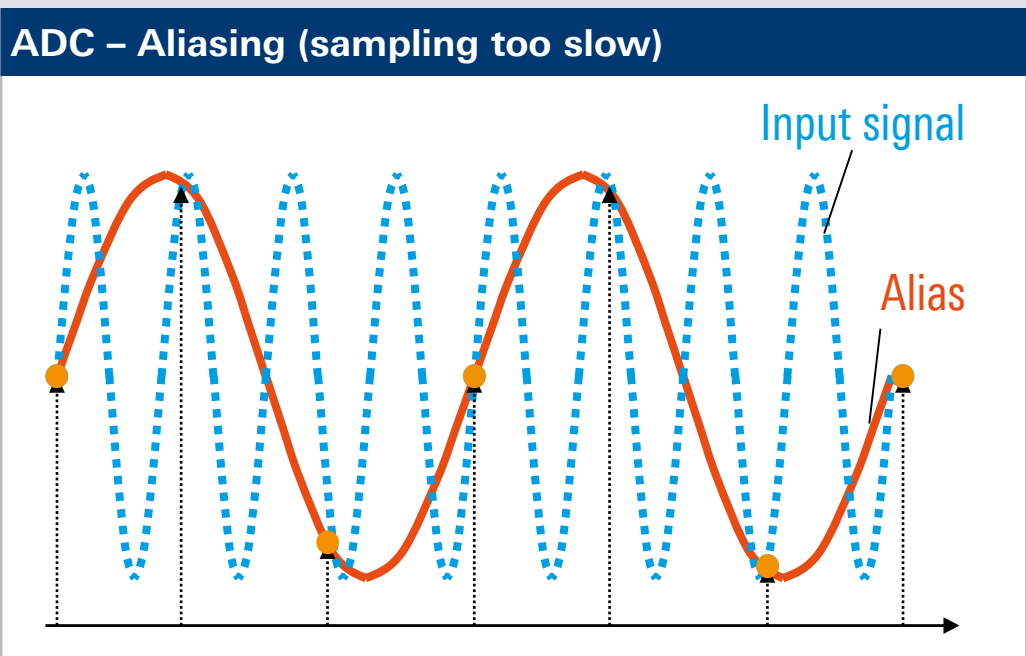
MEMORY DEPTH

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

► Captured time = $\dfrac{\text{memory depth}}{\text{sampling rate}}$

► 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
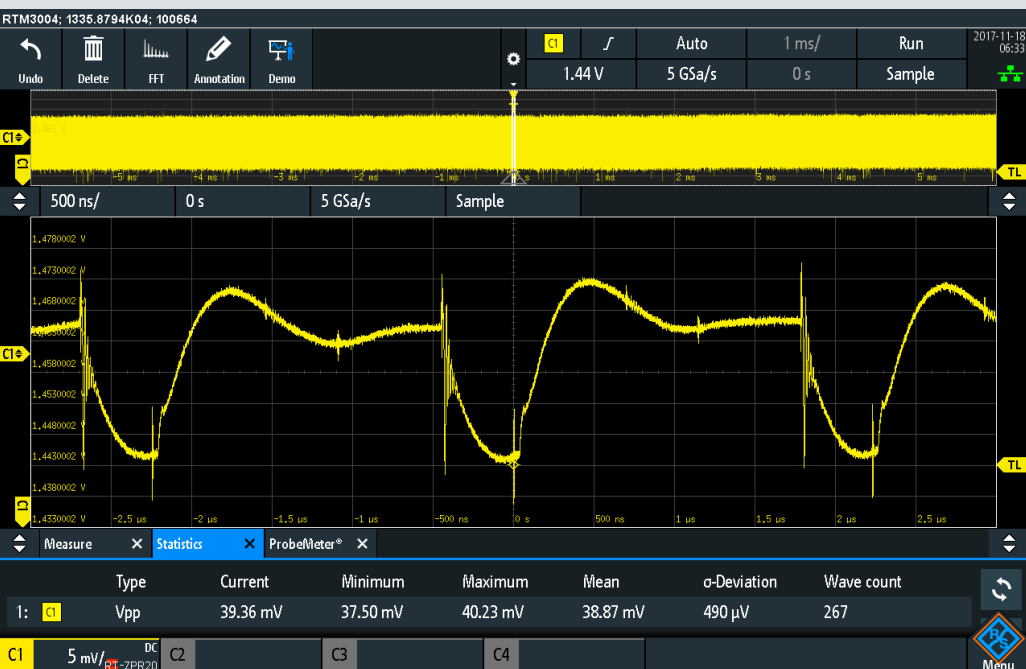
VERTICAL RESOLUTION

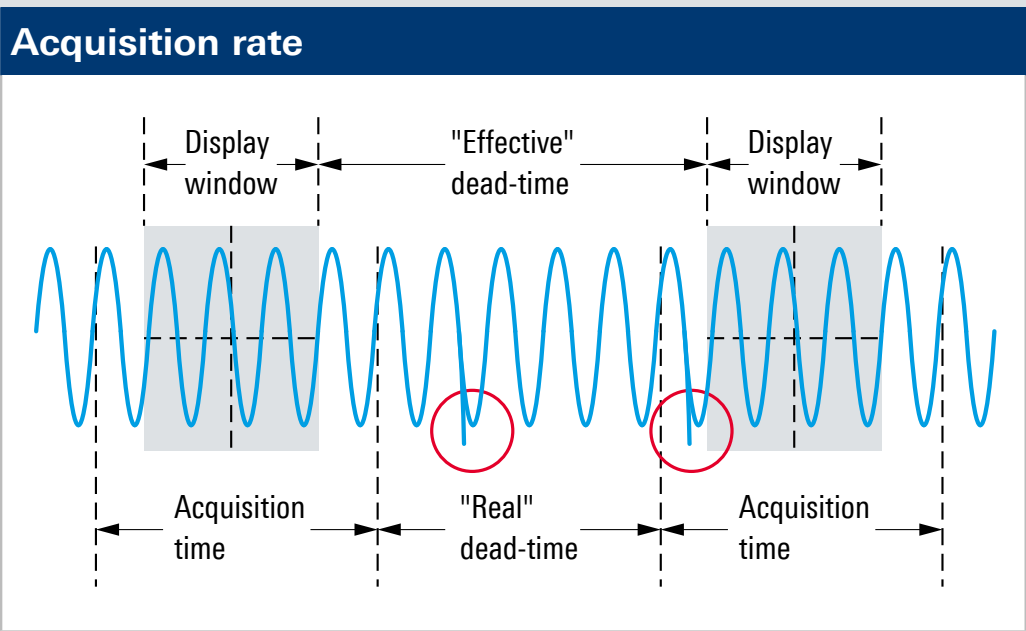**The vertical resolution of an oscilloscope is determined by the oscilloscope's ADC.**

► An 8-bit ADC can place an input signal into any of 256 (2^8) vertical levels, while a 10-bit ADC has 1024 (2^{10}) 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

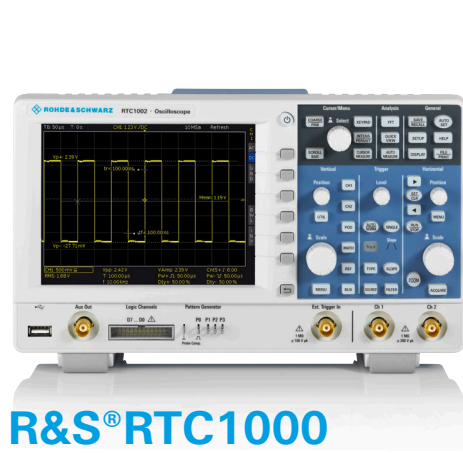► The high resolution mode averages adjacent signals and can be used on all signals

10-bit A/D converter: uncovers even small signal details

4 mV / 1 mV
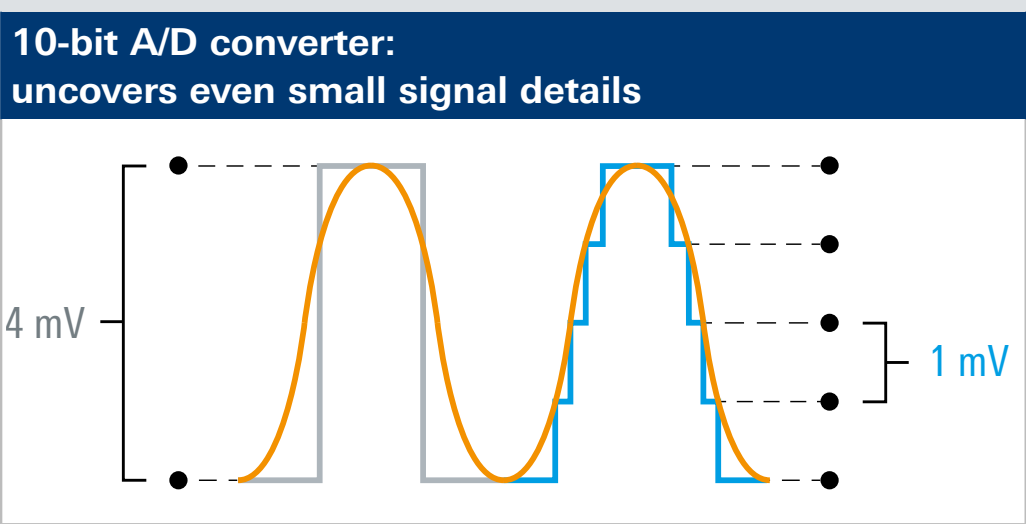
ACQUISITION RATE

The acquisition rate is the number of times/s the oscilloscope can capture and display waveforms.
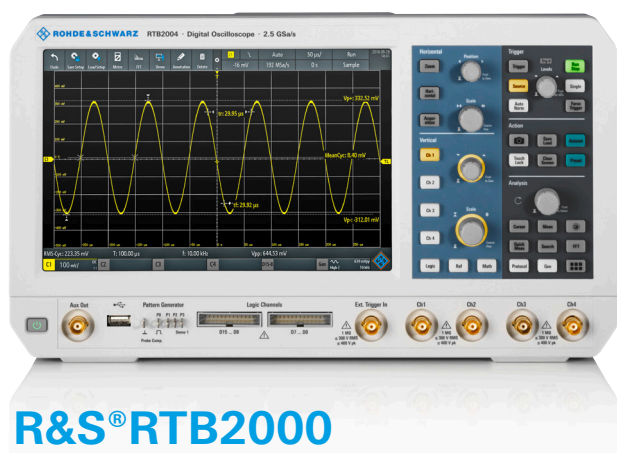
► Oscilloscopes with faster acquisition rates have less dead time between acquisitions

► 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

Acquisition rate

Display window / "Effective" dead-time / Display window / Acquisition time / "Real" dead-time / Acquisition time

OSCILLOSCOPE INNOVATION. MEASUREMENT CONFIDENCE.

R&S®RTC1000

R&S®RTB2000

Multi Domain

R&S®RTM3000

Multi Domain

R&S®RTA4000

Multi Domain

R&S®Scope Rider RTH

HD 16 bit / Multi Domain

R&S®RTE1000

HD 16 bit / Multi Domain

R&S®RTO6

HD 16 bit / Multi Domain
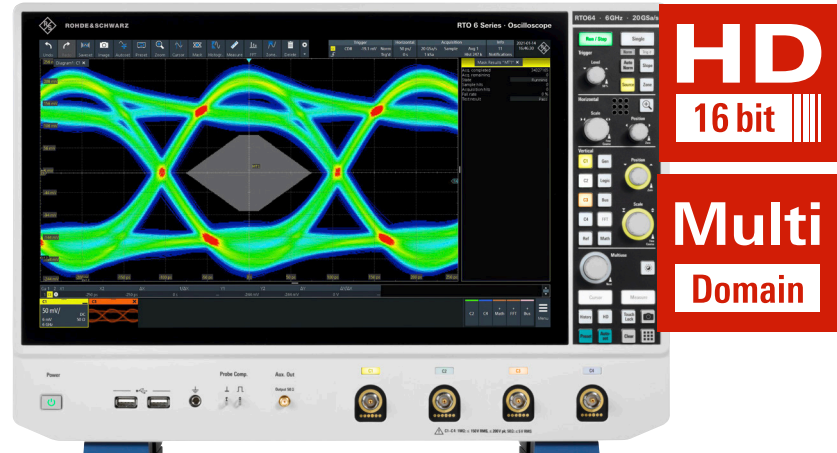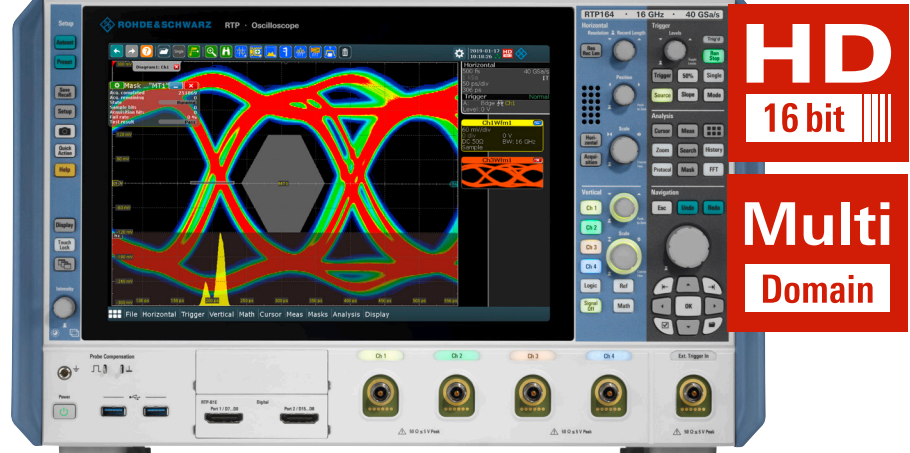
R&S®RTP

ROHDE & SCHWARZ

Make ideas real

PD 5214.9496.82 | V 03.00 (xx)