Measuring small signals accurately

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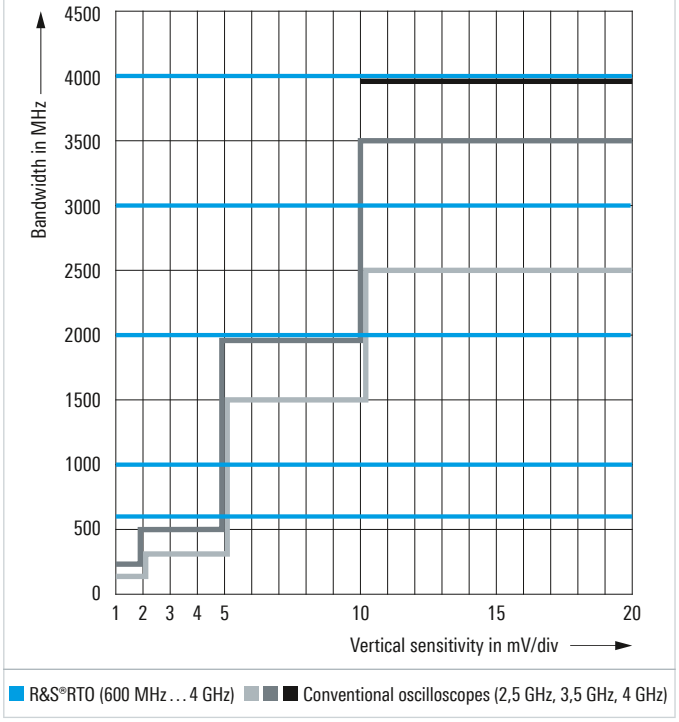
For measurement settings below 10 mV/div, oscilloscopes typically reduce the measurement bandwidth in order to keep the trace noise as low as possible. The R&S®RTO is different: It offers the full bandwidth even for the most sensitive settings, and an A/D converter with more than 7 effective bits (ENOB) digitizes the signal.

Sensitivity versus bandwidth



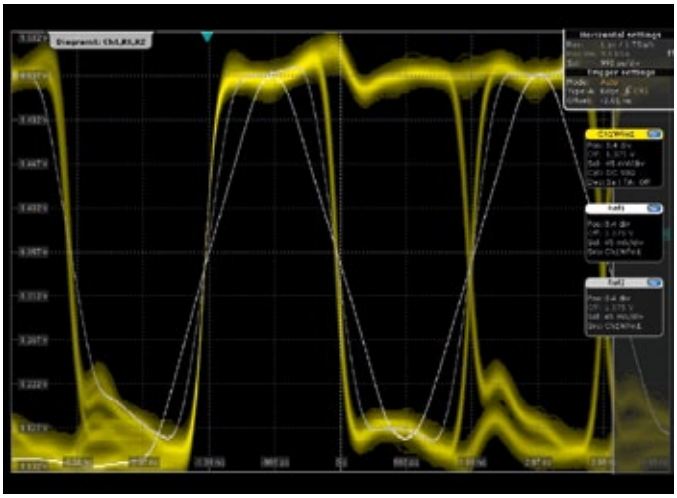
Graphic 1: The R&S®RTO oscilloscopes offer full measurement bandwidth, even at high vertical input sensitivity of up to 1 mV/div.

Your task

Mobile devices are becoming increasingly smaller and offer more and more functions, yet users still expect them to have a long battery life. Optimizing power consumption is one of the most challenging aspects of designing these devices. Supply voltages need to be kept as low as possible in order to minimize power consumption when transmitting at high data rates. Low-swing signals in line with the low voltage differential signaling (LVDS) standard are used. Signals with low amplitude are also common in analog and mixed-signal circuits such as in D/A converters and amplifiers, which use very low voltages for the reasons previously mentioned. Conventional oscilloscopes cannot display the full bandwidth of such signals at high vertical sensitivity. It is very difficult or impossible to measure signals with high fidelity – a problem which the R&S®RTO now helps to solve (see graphic 1).

T&M solution

Active probes used for measuring high-frequency signals typically have a voltage divider ratio of 10:1, which reduces the signal amplitude of the already small signals to one-tenth of the source. When measuring an LVDS signal with a voltage swing of 350 mV, only 35 mV arrive at the oscilloscope input. The vertical scaling needs to be set to 40 mV/div or 4 mV/div to optimally display this signal (see graphic 2). The R&S®RTO oscilloscopes operate down to the full 1 mV/div sensitivity with activated input amplifiers, taking advantage of the A/D converter's full dynamic range. Other oscilloscopes use software to simply spread the signal amplitude across the screen and therefore use only a small part of the A/D converter's range. In addition, the inherent noise of the R&S®RTO oscilloscope is so low that it does not need to be further reduced by decreasing the input bandwidth. The full bandwidth can be used for accurate measurements in all sensitivity ranges.

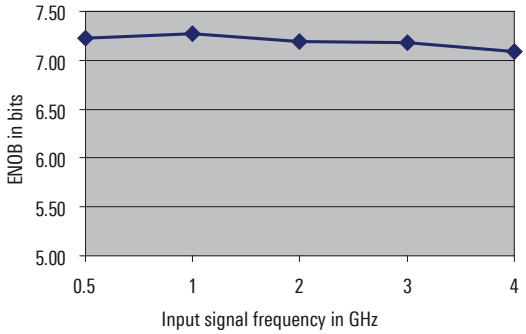


Graphic 2: This graphic shows a 500 Mbit/s LVDS signal with full bandwidth (yellow) as well as 500 MHz and 250 MHz filters (white reference traces) with an active probe. The vertical resolution is 40 mV/div (base unit: 4 mV/div due to the 10:1 attenuation caused by the probe).

High dynamic range due to single-core A/D converter

A measure of the true accuracy of signal digitization is the A/D converter's effective number of bits (ENOB). Especially the small signal amplitudes of high-speed digital buses place more stringent requirements on the dynamic range. 8-bit A/D converters are often used in high-bandwidth digital oscilloscopes. These converters consist of multiple, slow, time-interleaved converters that are connected. However, the higher the number of converters that are combined, the larger the errors that arise due to the fact that the behavior of the individual converters is not uniform. The R&S®RTO oscilloscopes do not have such limitations. The 10 Gsample/s converter in the R&S®RTO was implemented using single-core architecture, i.e. a single converter core converts the sampled analog signal to an 8-bit digital word. The single-core architecture minimizes signal distortion and achieves more than seven effective bits (see graphic 3). The accuracy of the measurement signal's representation also depends on the oscilloscope's bandwidth relative

Effective number of bits (ENOB)



Graphic 3: Accurate signal display and maximum dynamic range are ensured by the consistently high ENOB provided by the A/D converters used in the R&S®RTO oscilloscopes.

to the signal frequency and the frontend's inherent noise. This is why demanding design requirements were consistently implemented in the development of the R&S®RTO oscilloscopes. The effort paid off: The inherent noise of the oscilloscopes is the lowest in this class of instruments, for precise, stable results even at the most sensitive settings (see graphic 4).

Graphic 4: Low inherent noise, even at a vertical input sensitivity of 1 mV/div.

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