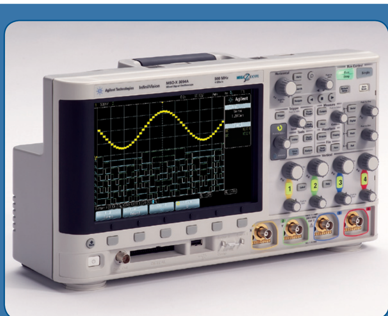
Oscilloscope Selection Tip 1: Bandwidth

Part 1 of a 12-part series

Tip 1 *Select a scope that has sufficient bandwidth to accurately capture the highest frequency content of your signals*



Agilent's InfiniiVision 2000 and 3000 X-Series oscilloscopes let you protect your investment and buy the bandwidth you need for today and tomorrow.

Many different oscilloscope specifications determine the accuracy with which signals can be captured and measured. But an oscilloscope's primary specification is its bandwidth. So what do we mean by "bandwidth"? All oscilloscopes exhibit a low-pass frequency response that rolls-off at higher frequencies, as shown in Figure 1. Most scopes with bandwidth specifications of 1 GHz and below typically have what is called a Gaussian frequency response, which approximates the characteristics of a single-pole low-pass filter. The lowest frequency at which the input signal is attenuated by 3 dB is considered the scope's bandwidth. Signal attenuation at the –3 dB frequency translates into approximately –30% amplitude error. In other words, if you input a 1 Vp-p, 100 MHz sine wave into a 100 MHz bandwidth oscilloscope, the measured peak-to-peak voltage using this scope would be in the range of 700 mVp-p (–3 dB = 20 Log (0.707/1.0). So you cannot expect to make accurate measurements on signals that have significant frequencies near your scope's bandwidth.

So how much bandwidth is required for your particular measurement applications? For purely analog signal measurements, you should choose a scope that has a bandwidth specification at least three times higher than the highest sine wave frequencies you may need to measure. At 1/3 a scope's bandwidth specification, signal attenuation is minimal. But what about required bandwidth for digital applications, the main use of today's scopes? As a rule of thumb, Agilent recommends that you choose a scope that has a bandwidth at least five times the highest clock rate in your systems. For example, if the highest clock rate in your designs is 100 MHz, then you should choose a scope with a bandwidth of 500 MHz or higher. If your scope meets this criterion, then it will be able to capture up to the fifth harmonic with minimum signal attenuation. The fifth harmonic of the signal is critical in determining the overall shape of your digital signals.

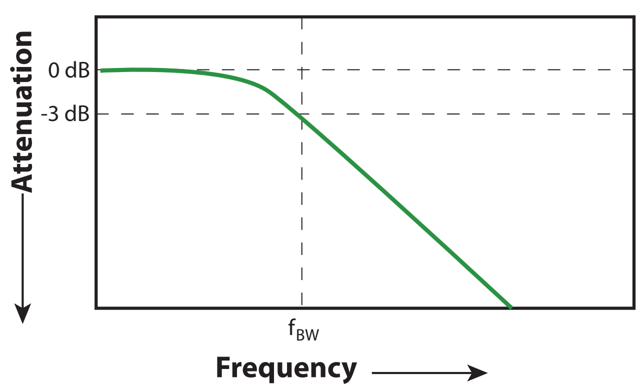


Figure 1. Oscilloscopes exhibit a low-pass frequency response that rolls-off higher frequencies.

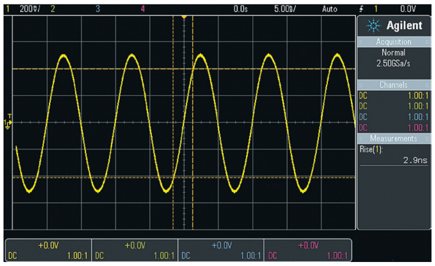


Figure 2. 100 MHz clock signal captured on a 100 MHz bandwidth oscilloscope.

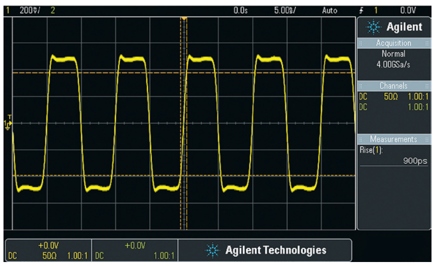
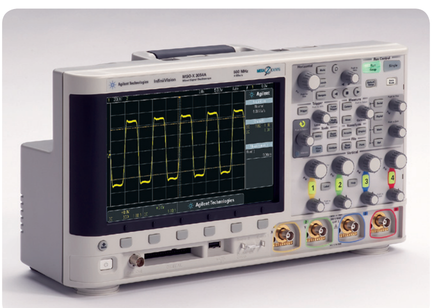


Figure 3. 100 MHz clock signal captured on a 500 MHz bandwidth oscilloscope.

Figure 2 shows an example of a 100 MHz bandwidth scope capturing and displaying a 100 MHz digital clock signal. In this case, the scope attenuates the higher frequency components and basically just shows the 100 MHz sine wave fundamental frequency of this signal. This scope has insufficient bandwidth to capture this signal. Figure 3 shows the same 100 MHz clock signal captured on a 500 MHz bandwidth scope. We can now see and measure more details of this digital signal using this higher bandwidth oscilloscope.

Note that the five-to-one rule-of-thumb recommendation (scope bandwidth relative to clock rate) does not take into account lower clock-rate signals that have relatively fast edge speeds. These signals may contain significant frequency components beyond the fifth harmonic. To learn more about how to determine required bandwidth based on signal edge speeds, refer to Agilent's application note Evaluating Oscilloscope Bandwidths for Your Applications (Agilent publication 5989-5733EN).



Protect your investments with bandwidth upgradability in Agilent InfiniiVision 2000 and 3000 X-Series oscilloscopes

If you are in the market today to purchase your next oscilloscope, Agilent Technologies' new 2000 and 3000 X-Series oscilloscopes come in various bandwidths ranging from 70 to 500 MHz. These oscilloscopes are the only ones in their class that offer bandwidth upgradability. This means that you can now protect your oscilloscope investment. Perhaps a 100 MHz bandwidth scope is all that you need and can afford today. But if your signal speeds increase in two years, you may then need a 500 MHz scope to make accurate measurements on your higher speed designs. No problem! If you purchase an Agilent Technologies InfiniiVision 2000 or 3000 X-Series oscilloscope today, you can easily upgrade the bandwidth of this unit in the future.

To learn more about Agilent's InfiniiVision 2000 and 3000 X-Series oscilloscope and mixed signal oscilloscopes, go to www.agilent.com/find/2000X-Series or www.agilent.com/find/3000X-Series.

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