WHITE PAPER

5 Common Mistakes to Avoid

When Buying a Low-Cost Oscilloscope

Choosing the right oscilloscope can be a challenging task. The goal is to make the best purchase decision by getting the functionality you need while saving money and maintaining quality.

This white paper will help you avoid the following five common mistakes when buying a low-cost oscilloscope:

- selecting an oscilloscope with insufficient bandwidth
- settling for a USB oscilloscope
- underestimating usability
- running the risk of equipment support difficulties
- focusing solely on specifications

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Mistake #1: Buying an Oscilloscope with Insufficient Bandwidth

An oscilloscope's bandwidth specification is the frequency at which the input signal sine waves attenuate by -3 dB (30%). Many engineers consider this specification first when selecting an oscilloscope. However, sometimes engineers often underestimate the total project requirements by just considering this attribute.

It helps to understand the frequency content of the signal you're measuring. All oscilloscopes exhibit a low-pass frequency response that rolls off at higher frequencies, as shown in Figure 1. Most oscilloscopes with bandwidth specifications of 1 GHz and below typically exhibit a Gaussian frequency response which approximates the characteristics of a single-pole, low-pass filter.

Signal attenuation at the -3 dB frequency translates into an amplitude error of 30%. For example, if you input a 1 V_{p-p}, 100 MHz sine wave into a 100 MHz bandwidth oscilloscope, the measured peak-to-peak voltage using this oscilloscope would be in the range of 700 mV_{p-p} (-3 dB = 20 log [0.707 / 1.0]). It is impossible to make accurate measurements on signals that have significant frequencies near your oscilloscope's bandwidth.

Be sure to take into consideration any future needs, such as an increase in signal speeds, that would necessitate more bandwidth. Bandwidth upgrades may be available depending on the oscilloscope vendor.

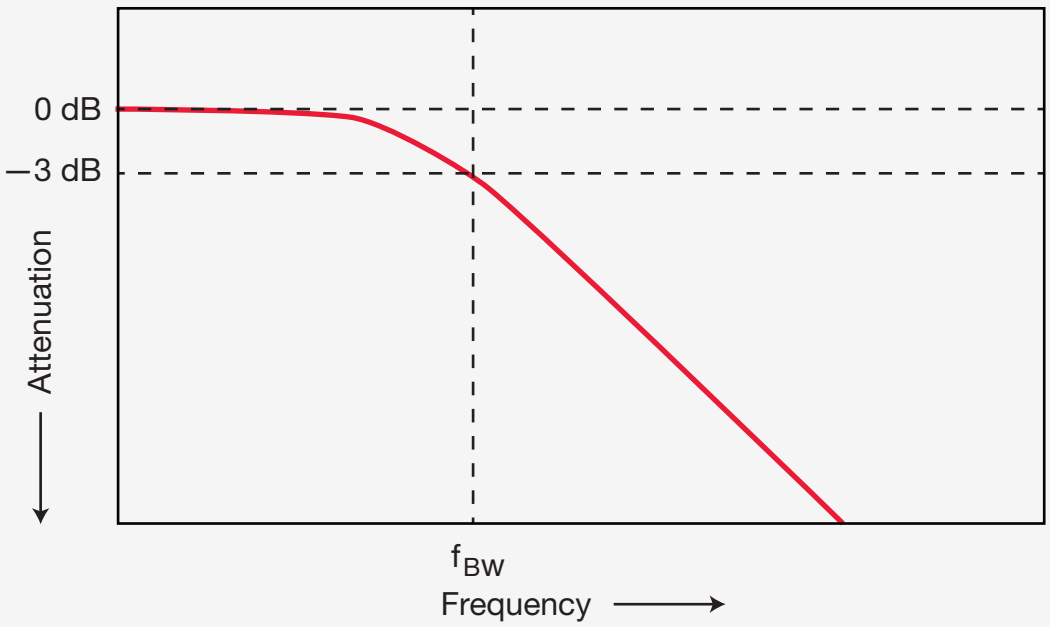


Figure 1. Oscilloscope Gaussian frequency response.

You may ask during the decision process, “My signals are 10 MHz, so a 30 MHz oscilloscope should be fine, right?” The answer is yes, but only if you measure sine waves. Meanwhile, square waves are composed of sine waves at the fundamental frequency and with an infinite number of odd harmonics. So, the rule of bandwidth equals three times the signal frequency isn’t always applicable.

Applications

Digital

One approach is to choose an oscilloscope with bandwidth at least five times the highest clock rate in your system under test. The oscilloscope can 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. Bandwidth of five times your digital signal’s fundamental frequency will help you efficiently debug digital signals.

Analog

The bandwidth requirements can be less stringent. Attenuation of the signal is minimal at one-third of an oscilloscope’s bandwidth specification. A bandwidth of three times your analog signal’s frequency should be sufficient for your measurement needs.

Pro tip

Digital signal — use a bandwidth that is at least five times higher than your fundamental frequency.

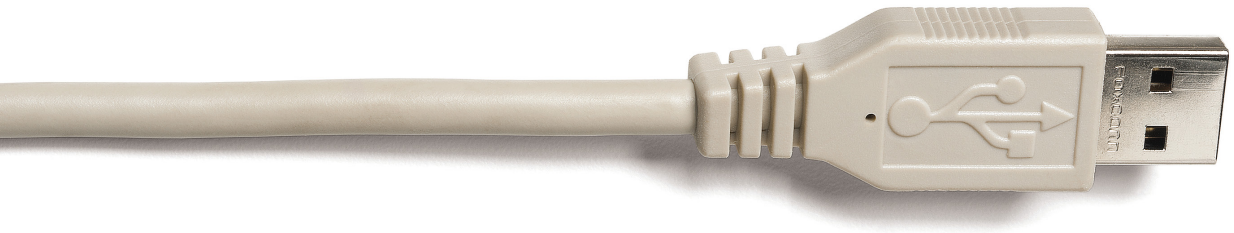
Analog signal — use a bandwidth that is at least three times higher than your fundamental frequency.

Mistake #2: Settling for a USB Oscilloscope

A USB oscilloscope may seem like a better option than a standalone oscilloscope because it is smaller, portable, and less expensive. However, key differences exist that make the USB option more complicated and costly when measuring and debugging systems.

You need a PC and possibly a waveform generator to use a USB oscilloscope. Now the total cost of the project increases, and more bench space is necessary compared to a standalone oscilloscope. In addition, you may have to purchase additional equipment if the USB scope does not contain all the functionalities to meet project requirements.

However, a standalone oscilloscope provides multiple instruments in one, such as a function generator, serial protocol analyzer, frequency response analyzer, and more, saving you money and valuable bench space.



Further differences between the USB oscilloscope and the standalone model include the device's user interface, scale ranges, and input ranges. A standalone oscilloscope contains usable, intuitive, and dedicated control knobs which provide an ergonomic user interface. The USB oscilloscope's graphical user interface (GUI) displayed on the PC lacks these tactile features. Additionally, the scale values and input ranges of the USB oscilloscope may not be a good fit for your project. It might provide only 1-2-5 full-scale ranges and contain a maximum capable input of 5 V.

When settling for a USB oscilloscope, you also miss out on the benefit of a repetitive waveform update rate. However, the USB device does not support live data transfer. Instead, it writes the captured data to an internal buffer then transfers it to the PC. Because the update rate on a USB oscilloscope is slower, glitches within the system are not visible or captured, thus hindering your ability to debug the design.

In contrast, the standalone Keysight 1000 X-Series oscilloscopes provide up to 200,000 wfms / seconds update rate that displays a more detailed signal.

Mistake #3: Underestimating Usability

How easy the oscilloscope is to use affects measurement productivity and is just as important as performance characteristics. An intuitive GUI, an accessible built-in help system, and straightforward selection knobs enhance usability and decreases the time spent learning how the oscilloscope works. You now have more time to make measurements.

Several factors contribute to an intuitive and detailed GUI that captures and clearly displays subtle waveforms. These characteristics include the display's quality, size, resolution, update rate, viewing angle, color versus monochrome, and user-specified display modes such as variable and infinite persistence. Additionally, a multi-language GUI can better contribute to the user's interaction with the oscilloscope.

An instrument that offers a built-in help system to answer questions about a feature or function while in use makes your oscilloscope easier to use. The help system explains how a feature works in real time, and it can also suggest instances in which a particular function is applicable for taking a measurement. Get useful tips about a specific feature by simply pressing and holding any button to access the help menu when using Keysight's 1000 X-Series oscilloscopes.

A user-friendly oscilloscope has knobs that directly control all frequently used variables such as vertical scale (V / div), vertical position, horizontal scale, horizontal position, and trigger, as shown in Figure 2. For example, it is important to quickly make fast Fourier transform (FFT) measurements and perform arithmetic operations when debugging. Dedicated knobs for adjustments and convenient buttons on the front panel for quick access can impact measurement precision and save you time when making measurements.

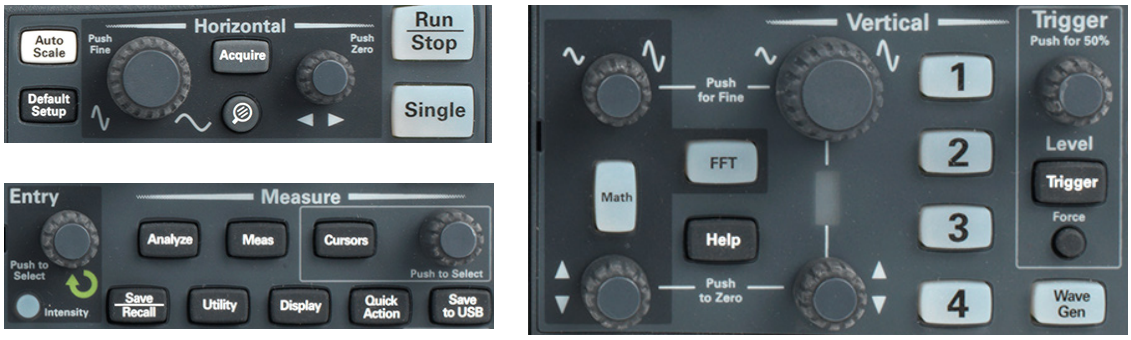


Figure 2. Oscilloscope front panels should include knobs for all key setup variables.

Mistake #4: Inadequate Equipment Support

Buying the oscilloscope is the first step, and continuing support for your instrument is next. There is always a possibility that you purchase a defective product and it malfunctions after you start using it, or you need an upgrade for unanticipated requirements. When these challenges arise, buyers often find that the warranty does not cover the problem or the repair and replacement service is extremely difficult. Be sure to research the support and services offered by the vendor before buying to avoid support issues.

Evaluate the manufacturer

Is the manufacturer's name reputable? Choose a company that is a recognized industry leader and has demonstrated integrity in resolving problems. It is possible to make the mistake of purchasing a low-cost scope without considering the manufacturer's reliability, responsiveness, and professionalism. Consider software quality, measurement expertise, and available services when shopping.

Training and support materials

Many inexpensive oscilloscopes do not contain integrated help features and only include a manual with the instrument when shipped. This practice is a concern for all low-cost oscilloscope buyers, especially educators who benefit from tools like built-in training signals and educational labs. Instead of turning to the internet for advice, understand what training and support materials are available before purchasing.

Local support and servicing

When a problem occurs, a vendor with a wide network of support engineers and service locations increases expertise availability and decreases downtime. A less established vendor may use a third-party provider for service requests that can cause further repair delays. Evaluate the accessibility of software updates offered and know the warranty duration provided when choosing a vendor.

Keysight's InfiniiVision 1000 X-Series includes 70 MHz oscilloscope models that can be inexpensively and easily upgraded to 200 MHz models through the purchase of a software license.

Mistake #5: Focusing Solely on Specifications

Comparing banner specifications between oscilloscopes may seem logical to select an instrument while shopping, but specifications do not tell the whole story. You need to dig deeper, read between the lines, and ask questions when researching oscilloscopes to select one that best fits your needs.

Deep memory versus segmented memory

An oscilloscope's memory depth determines the amount of time the oscilloscope can capture at a specific sample rate. Purchasing an expensive oscilloscope with deeper memory and single-shot acquisition is an option when the measurement requires capturing a long time span while digitizing at a high sample rate. Buying an inexpensive oscilloscope that offers segmented memory acquisition is another option. Figure 3 shows how segmented memory acquisition can extend the oscilloscope's total acquisition time by dividing the available acquisition memory into smaller memory segments. When combined with serial bus protocol decoding and triggering, you can use this acquisition mode to debug serial applications more effectively.

One common misconception is that it's best to have more memory. However, deep memory is more expensive and can obstruct data acquisition. Some oscilloscopes with deep memory maximize memory depth automatically, which causes the instrument to be sluggish and difficult to use. Choosing an oscilloscope with segmented memory is the clear solution to using memory efficiently while maintaining fast speeds.

Additional specifications to consider when purchasing a scope are:

- noise floor
- maximum input range
- minimum V / div settings
- FFT capabilities

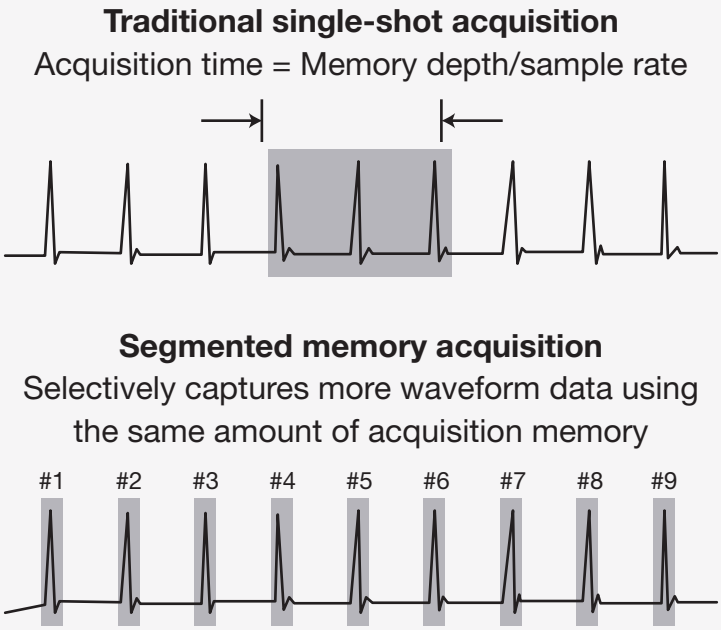


Figure 3. Single-shot acquisition vs. segmented memory acquisition.

Summary

When shopping for an oscilloscope, be sure to do your research and consider all the variables to ensure you are getting a quality product at a reasonable price. By avoiding the mistakes mentioned in this white paper, it is possible to find an inexpensive, reliable oscilloscope without sacrificing features such as bandwidth, usability, speed, or support.

Learn More

Check out Keysight's InfiniiVision 1000 X-Series oscilloscopes. Get professional-level, quality measurements and functionality that fits every budget.

www.keysight.com/find/1000X-Series

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