Choosing Your Next Value-Priced Oscilloscope

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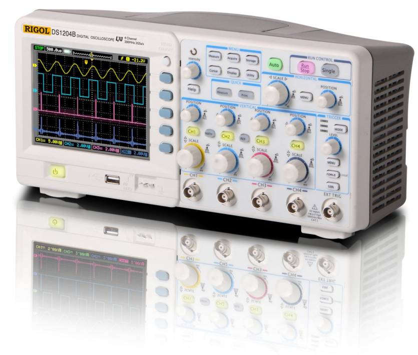

Choosing the best oscilloscope to suit your needs with budget-constrained funds can be a daunting proposition. Finding a scope that will enable you to do what you need efficiently and accurately means you have to pore over a host of specifications, some of which may or may not apply to your situation or tasks.

Digital oscilloscopes have come down in price amazingly over the past few years, but can you get a good scope for around $1,000? Do you really need some of the more advanced scope features like math calculations or deep memory depth? Single-shot, delayed sweep, pre-trigger acquisition, parametric measurements, saving waveforms and data for later analysis, noise reduction, averaging, searching, zooms, and math measurements give you helpful troubleshooting and analysis tools but these can be extras you may not need.

Here are some suggestions to aid your selection process and avoid some common mistakes.

First Thoughts

Ask yourself the following measurement questions about your requirements:

- What signal amplitudes will I be measuring (max/min)?
- What is their highest frequency?
- Do I need frequency domain (spectrum analysis) too?
- Do you need automatic measurements?
- Will you have a laptop PC available (so you can use a USB PC scope adapter) or must this be a standalone solution?

Answers to these questions and considering the topics below will help in your selection process.

Sampling Rate/Bandwidth

Bandwidth

What sort of signals do you want to display? For instance, a microprocessor system clock may be the highest frequency signal the scope you will want to display. So your oscilloscope should have a bandwidth of 3 - 4 times greater than this clock frequency, in order to display the waveform adequately. If, however, you want to accurately see the rise-time of the clock, you'll need around 10 times that frequency as a sample rate.

Bandwidth is arguably the single most important property of an oscilloscope, determining the range of signals that can be displayed. It also dictates price range, since it is much harder and more expensive to make really fast scope circuitry. Bandwidth can be defined as the maximum frequency of signal that can pass through the front-end circuitry (amplifiers, attenuators, ADCs, interconnects, relays), so the analog bandwidth of your scope must be higher than the maximum frequency that you wish to measure. Most scope manufacturers define bandwidth as the frequency at which a sine wave input signal is attenuated to 71% of its true amplitude (-3 dB point) - the displayed trace amplitude will be 29% in error at this frequency! So try to purchase a scope with a bandwidth five times higher than the maximum frequency signal you wish to measure. Higher bandwidth scopes are increasingly expensive, so you may have to compromise here. On some scopes, the quoted bandwidth is not available on all voltage ranges, so check the data sheet carefully; and be alert that scopes usually have different sampling rates depending on the number of channels in use. Typically, the sampling rate in single channel mode is twice that in dual channel mode.

Sample Rate
Sample rate is usually specified in Megasamples per second (MS/s) or Gigasamples per second (GS/s). The Nyquist criterion states that the sampling rate must be at least twice the maximum frequency that you want to measure in order to display a particular frequency. But for a scope you really require at least 5 samples to accurately reconstruct a waveform.

Most scopes confusingly describe two different sampling rates: real time and equivalent time sampling – often called repetitive sampling. This only works for stable and repetitive signals, since this mode builds up or reconstructs the waveform from multiple successive acquisitions. Because repetitive sampling digitizes the waveform over a number of cycles it can only be used to measure stable signals like square-wave clocks, but is not capable of recording really fast single-shot or non-repetitive signals.

Resolution and Accuracy
In digital electronics, measuring a signal change of 1% is usually ok, but in audio electronics, 0.1% distortion or noise can be a showstopper. Most modern DSOs are optimized for use with fast digital signals and only offer 8 bit resolution (8 bit ADC), so can detect about a 0.4% signal change. With 8 bit resolution, the voltage range is divided up into 256 vertical steps. With a ±1 V range selected, this corresponds to around 8mV per step. This may be adequate for viewing digital signals but may be inadequate for viewing analog signals, especially when using a built-in FFT spectrum analyzer function. For applications such as audio, noise, vibration and monitoring sensors (temperature, current, pressure) an 8 bit oscilloscope is often not suitable and you should consider 12 or 16 bit alternatives. Most bench scopes are 8-bit devices, however.

A DSO's accuracy is not usually regarded as too important. You can make measurements within a few percent (8 bit DSO's often quote 3 - 5% DC accuracy) but for more accurate measurements you should use a multimeter. With a higher resolution oscilloscope (12 bits or more) more accurate measurements are possible (1% or better)

Memory Size
The scope's A/D converter digitizes the input waveform and the resulting data is saved to high-speed memory. Memory depth specs may often be overlooked, but this can be one of the most important features to compare. Captured samples are stored in a digital buffer memory, so, for a given sampling rate, the size of the buffer memory determines how long it can capture a signal for before the memory is full. The relationship between sampling rate and memory depth is important; a scope with a high sampling rate but small memory will only be able to use its full sampling rate on the top few time-bases. For instance, 100µs of a signal captured with a scope with 1 k buffer limits the sampling rate to 10MS/s (1 k /100 µs) even though the scope may be capable of sampling at 200 MS/s.

When an oscilloscope acquisition memory is as large as 1M samples, then complex signals can be zoomed in and analyzed or even found where otherwise they would be missed. Single-shot measurements and glitches can be displayed too.

Waveform Update Rate
An oscilloscope's update rate is its ability to make repetitive measurements with minimal dead intervals between samples. A fast update rate makes the display more responsive to rapidly-changing signals. A major factor in the quality of an oscilloscope display is its update rate. Faster update rates improve the probability that infrequent events, such as glitches, are captured.

Triggering Capabilities
Edge triggering is the most common form of signal capture for general-purpose oscilloscope users, but additional triggering power in some applications. Advanced triggering options can save a significant amount of time in day-to-day debugging – video line or frame triggering for instance. If you need to capture a narrow event, pulse triggering permits you to trigger on a positive-going or negative-going pulse greater than, or less than, a specified width.

Probing Questions

The probe that often comes free with the scope is important to evaluate too because this can constrain the total system bandwidth, which is limited by the combination of the two bandwidths. Consider, for example, a 100MHz oscilloscope coupled with a 60MHz passive probe. With this combination, you will not be able to obtain the full bandwidth of the 100MHz oscilloscope, but will instead be limited to the 60MHz allowed by the probe. Some probes are clunky, and some lack the ability to remove the spring tip to reveal a point-tip, useful for probing surface-mount devices.

Connectivity Capabilities

Digital oscilloscopes usually offer a variety of connectivity capabilities. These can include RS-232, LAN, and USB 2.0 interfaces for control or data download. USB sockets for memory sticks are also useful for transferring data to PCs for reports, etc. Some oscilloscopes let you export waveform data as Excel files, while others only allow you to store screen captures as jpg images.

Both are useful for printing out results or entering into Word files. The ability to perform "hands-off" scope control via a PC may be vital to your needs, or irrelevant, but worth considering.

Built-in Capabilities

Automatic measurements, built-in pass/fail analysis with relay output, and math functions can save time and make your life easier. Measurement statistics, reference waveform storage, and FFT (Fast Fourier transform) capabilities are available on many oscilloscopes, allowing you to display modified signals or frequency spectra. Averaging helps to remove noise issues, digital persistence allows you to spot glitches the easy way; math capabilities mean you can invert, add, subtract, multiply and divide channels, or sometimes even create your own functions.

Ease of Use

Some scopes offer "one-touch" automatic setup, or a number of memorized set-up configurations, increasing a scope's ease of use. Others include a built-in help system to save you constantly referring to the manual. Some scopes dispense with dedicated, user-friendly rotary knobs, and replace them with cheaper buttons for often-used adjustments such as vertical sensitivity, time-base speed, trace position, and trigger level. Download the scopes manual from the vendor's website will give you an indication of how intuitive it is to operate the oscilloscope while concentrating on your circuit under test. Finding an oscilloscope that is easy to use can save you a great deal of frustration later. Also, check if the scope's software is upgradeable at no charge and easily via an Internet connection. And finally, check the length of warranty. If your unit fails in use, will the vendor make repair an easy process?

Conclusions

There are economical scopes available now with capabilities that rival the big name manufacturers at $1,000 or below. At Saelig Co. Inc. we have assembled the widest range of affordable scope solutions, from low-end 2MHz USB scope adapters at under $180, to sophisticated standalone scopes that rival the big names, to high-end 2/4 channel mixed-signal adapters that cover 100MHz signals as well as offering 8/16 channels of simultaneous logic analysis remotely via Ethernet from anywhere in the world, and even up to the world's-fastest 12GHz sampling scope adapter. Details at http://www.saelig.com/category/PS.htm

2 Channel 100 MHz Economy Comparison Chart

	RIGOL DS 1102E	TEK TDS 1012B	Instek GDS 1102	LeCroy 112	B&K 2542
Channels	2	2	2	2	2
Bandwidth	100 MHz	100 MHz	100 MHz	100 MHz	100 MHz
Max Sample Rate	1 GSa/s	1 GSa/s	250 MSa/s	500 MSa/s	1 Gsa/s
Sample rate (all channels)	500 MSa/s	1 GSa/s	125MSa/s	250 MSa/s	500 Msa/s
Max Memory	1 Meg	2.5K	4K	4K	4K
Max Memory (All channels)	512K	2.5K	4K	4K	4K
Display Type	TFT	Monochrome	TFT	Color	Color
Display Size	5.7"	5.6"	5.6"	5.7"	5.7"
Triggers	Edge, Slope, Pulse, Alternate, Video	Edge, Pulse Video	Edge, Pulse Video	Edge, Slope, Pulse, Alternate, Video	Edge, Pulse Video
Measurements	22	10	19	32	19
Math functions	Addition, Subtraction, Multiply & FFT	Addition, Subtraction, Multiply, Divide & FFT	Addition, Subtraction & FFT	Addition, Subtraction, Multiply, Divide & FFT	Addition, Subtraction, Multiply, Divide & FFT
Price	$795	$1,320	$949	$1,200	$1,155
The DS 1102E is this percentage less cost than	0%	40%	16%	34%	31%