Recent Advances in Oscilloscope Capabilities

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The latest measurement capabilities for oscilloscopes include higher bandwidths and real time display. Capturing intermittent signals, a persistent measurement problem, has finally been solved by higher update rates. Advances in triggering have also made it quicker and easier to troubleshoot glitches, runts and other problems. Here's a look at what's new in oscilloscopes and what to consider when making a purchase.

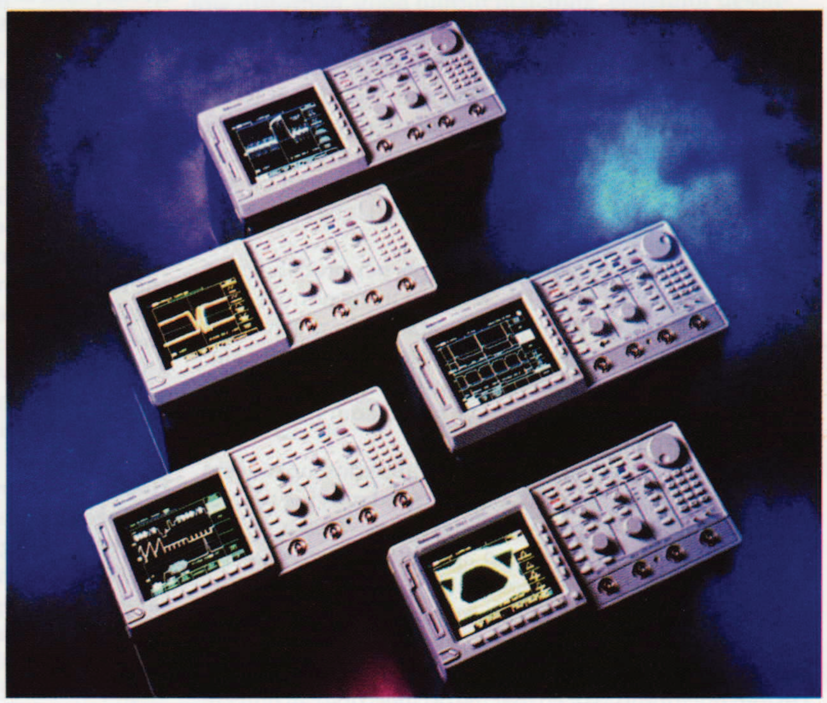
Oscilloscopes have changed tremendously in the last ten years. All of the changes have the same goal in mind as the original oscilloscope built many years ago: show the user a picture of what is really happening to the signal. The last ten years of changes simply allow the user to more quickly and easily display the right picture, especially in today's world of more complex signals. The predominant changes include a move to higher bandwidths, availability of real-time oscilloscopes, dramatic increases in the update rates of digital oscilloscopes, and significant new triggering options. Other important changes include the availability of different acquisition modes to see specific signal details, plus features that make oscilloscopes easier to use, like printer support, built-in floppy disk drive and automatic measurements.

Move to Higher Bandwidths

When customers are surveyed as to why they purchased their most recent oscilloscope, bandwidth tops the list. The need for more oscilloscope bandwidth is driven by faster circuitry found in applications as diverse as personal computers, communications equipment, medical instrumentation, avionics, video and automotive electronics. Typical oscilloscope bandwidths for these applications range from 500 MHz to 1 GHz. A good rule of thumb is to have the oscilloscope's bandwidth be at least five times the bandwidth of the fastest signal to be measured.

Move to Real-Time Signals

Many of today's signals are classified as "real time," which means that they are not periodic and, hence, do not repeat. An example of several real



Latest model oscilloscopes from Tektronix, Inc.

time signals are those found on a microprocessor's bus. Another example of a real time signal is a glitch.

A conventional analog oscilloscope cannot see these signals because the display is not bright enough. Even if a specialty analog oscilloscope is used, such as a microchannel plate oscilloscope, so that the real time signal can be seen, it will not remain on screen long enough for easy analysis.

Conventional digital oscilloscopes cannot see these signals because they have inadequate sample rate. Nyquist observed that a signal must be sampled at a rate greater than twice its highest frequency component in order to be successfully reconstructed using an ideal sine x/x filter. In reality, sine x/x filters used in oscilloscopes require that the signal be oversampled, not by a factor of 2, but by a factor of 2.5 to 4. Digital oscilloscopes that do not meet this sample rate requirement will either show the signal incorrectly or will require that the signal repeat in order to show it correctly.

Real time oscilloscopes have enough sample rate to show the signals completely the first time they are acquired. Often more than one signal must be observed simultaneously, so real time oscilloscopes typically have high sample rates across all of their channels.

In order to match today's high bandwidths of 500 MHz and 1 GHz, real time oscilloscopes typically have sample rates around 2 and 5 GS/sec.

Need for High Update Rates

Troubleshooting to locate a glitch can be one of the most difficult tasks an engineer faces. The engineer may suspect a signal is glitching, probe it and find that it looks like what she expected from the timing diagram produced by her simulation. If she uses an analog microchannel plate oscilloscope, she can be reasonably assured of seeing the glitch (although she may not see it long enough to analyze it!)

If she chooses a digital oscilloscope, her probability of capturing that glitch is greatly reduced using normal edge triggering, because the oscilloscope spends much more time processing the signal than it does capturing the signal. A signal that an analog microchannel plate oscilloscope may display in seconds may take hours or days to be seen on a digital oscilloscope.

About a year ago, the first digital oscilloscopes were introduced to overcome this problem and provide update rates comparable to analog oscilloscopes. This new feature is called "InstaVu™" and allows the user to see infrequent signals like glitches quickly and with all of the advantages of a digital oscilloscope: storage, automatic measurements, specialty triggering and more. InstaVu works by directly processing the incoming data with a custom microprocessor so that the oscilloscope can quickly accept another trigger.

Need for Special Triggering

Sometimes the oscilloscope user is trying to find a very specific signal condition. Examples include looking for a dropped microprocessor clock, finding a glitch, locating a runt (neither a valid digital "1" or "0") as a result of a metastable, or observing the result when a specific pattern is found across multiple signals. Using normal "+" or "-" edge triggering may or may not find the signal condition, especially given the significantly slower update rates of most digital oscilloscopes. Special triggering modes allow the user to quickly and easily locate these kinds of signals by selecting the type of signal to use as a trigger (glitch, pulse width, time-out, runt, time-qualified pattern, state, video, etc.)

Once the type is selected, the user sets up the right voltage and time conditions as appropriate for the kind of signal he is trying to see. The oscilloscope will display the next occurrence of this signal condition, regardless of the oscilloscope's update rate.

Need for Different Ways to Acquire and Display the Signal

All digital oscilloscopes can acquire the user's signal by sampling the signal and saving the corresponding voltage levels into the oscilloscope's memory. This method leaves out useful information in between the sample intervals, such as glitches or peak-to-peak noise levels. Digital oscilloscopes include many different ways to acquire and display the signal besides simply displaying the raw sampled waveform.

Peak Detect

If the user is looking for peak-to-peak noise levels or glitches, peak detect is a good way to acquire the signal. When peak detect is enabled, the oscilloscope will save the minimum and maximum voltages that occur over the entire sample interval. The entire waveform memory is filled with these minimum and maximum samples, and the result is displayed on screen. This mode is most useful at slower sweep speeds, when the oscilloscope is not sampling at its maximum sample rate. Peak detect works on a single acquisition of the waveform.

High Resolution

When the user is in a noisy environment and is trying to extract the signal from the noise, high resolution is very helpful. When high resolution is enabled, the oscilloscope saves the average value of the voltage between sample intervals and displays the result on screen. This mode is most useful at slower sweep speeds, where the most averages occur. High resolution works on a single acquisition of the waveform.

Envelope (Min/Max)

Envelope mode is useful for looking for peak-to-peak noise or jitter over multiple cycles of a waveform. Each incoming waveform is compared to the previous waveforms, and the minimums and maximums of the comparison are saved. Envelope mode requires signals to repeat.

Average

Average mode is useful in solving the same problems as high resolution, as long as the signal repeats over several cycles. Average mode simply takes longer than high resolution (the slower the sweep speed, the longer it takes) to achieve a comparable display. Each incoming waveform is averaged with the previous waveforms, and the result is displayed.

FastFrame (Segmented Memory)

When the user wants to acquire at faster update rates than a conventional digital oscilloscope, but still be able to see every acquisition, FastFrame is an alternative. An example of this type of application is laser testing, where the researcher wants to capture every cycle of a laser pulse and be able to distinguish between each pulse. This cycle time is faster than the typical digital oscilloscope's 10 Hz to 100 Hz update rate.

FastFrame mode takes the long record length of a digital oscilloscope and allows the user to partition it into several shorter chunks. Each chunk represents a single acquisition. Once a chunk is filled, the next acquisition cycle begins immediately so that the oscilloscope can accept the next trigger. This continues until all of the chunks are filled. For example, one configuration would be to partition a 50,000 point waveform into twenty-five 2,000 point chunks.

Ability to Use the Oscilloscope Quickly and Easily

In today's world of faster and faster product development cycles, the user does not want to have to spend a great deal of time learning how to operate his oscilloscope. Things to consider when deciding whether an oscilloscope is easy to use include:

- button and knob placement and labeling
- use of icons
- color or monochrome display
- printer support
- floppy disk drive support
- ability to import data into word processor or spread sheet
- automatic measurements and cursors
- autosetup
- help text incorporated into oscilloscope

Ease of use consistently ranks among the top purchase criteria for oscilloscopes.

Conclusion

The function of oscilloscopes as a troubleshooting and verification tool has not changed over the last several years, but the way oscilloscopes help the user troubleshoot and verify their signals has changed. Many of the signals are much faster and are real time only, and oscilloscopes have evolved to be able to capture these signals. Oscilloscopes have also improved greatly in the areas of acquisition modes and triggering. Features that make the oscilloscope easier to use have also evolved. When considering an oscilloscope for use, the following questions should be answered before a selection is made:

1. Will the oscilloscope be used for one or many applications?
2. Are these applications similar or diverse?
3. What kind of documentation support will be needed?
4. Are the signals real time only, or do they repeat?
5. How many signals need to be examined simultaneously?
6. How fast are the signals?
7. Is special triggering needed to capture the signals of interest?
8. Is the oscilloscope's update rate critical to capture glitches and signal changes?
9. How easy is the oscilloscope to use?
10. What kind of accuracy is needed to faithfully recreate the signal?
11. Are special processing functions like integrate, differentiate and FFT needed?

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