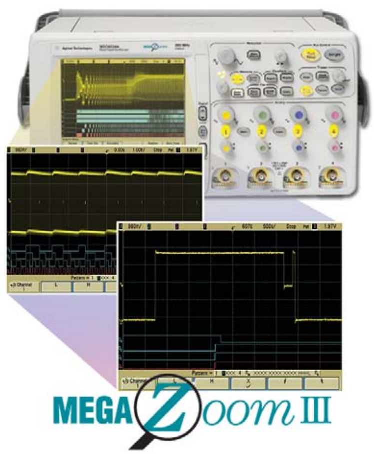
Deep-Memory Fast Response Oscilloscopes: The New Tools of Choice

Application Note 1446



Who should read this document?
This application note is for design engineers in R&D working with both analog and digital components. This document discusses the benefits of deep memory oscilloscopes for helping users view more of their design's signals. In particular it examines how deep memory oscilloscopes enable the user to view longer time spans and maintain the maximum sample rate over a broader range of time base settings.

Memory affects time capture
Deep memory oscilloscopes are moving beyond their traditional roles as specialized instruments and are fast becoming the tools of choice for today's engineers. These scopes are valuable for a wide range of characterization and debugging tasks. Why is this the case? Because deep memory scopes allow users to see more of their signals.

Traditionally the concept of "seeing more" meant observing a device's response over a longer time span, and this is indeed one of the key contributions such scopes make. Longer time captures mean acquisition of more information surrounding the events of interest, and this in turn enables more insightful analysis. For example, longer time spans are important for capturing the serial signals that are increasingly appearing in today's designs.

Memory affects sample rate
Longer time captures are only part of the deep memory story. Another important part is sample rate. What does sample rate have to do with deep memory? Everything, as it turns out.

Obtainable sample rates are a direct function of memory depth because a scope must manage the memory it has according to the user's instructions (time base setting) about the time span to be captured.

Suppose the user sets the scope's time base control to 100 µs per division. This means that a full screen represents 1 ms of time, and the scope must determine the highest sample rate it can apply to capture a 1 ms time span without exhausting its memory. If the scope has a maximum sample rate of 5 GSa/s and 10 k of memory, the actual sample rate will be no higher than 10 MSa/s (10 k samples / 1 ms). This is significantly less than the scope's maximum specified sample rate, and it exposes the user to all the consequences of undersampling, including aliasing, missed signal details, and incorrect measurements. These are serious problems for shallow memory scopes. The maximum sample rate may be impressive, but it may only be obtainable at the fastest few time base settings of the oscilloscope.

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Deep memory means higher sustained sample rate

Deep memory scopes enable the maximum sample rate to be maintained over a much broader range of time base settings. For example, the Agilent 6000 Series mixed signal oscilloscopes, which have up to 8 M points of acquisition memory, can maintain their maximum 4 GSa/s real-time sample rate, even at the 100 µs/div setting used in the previous example.

The graph in Figure 1 shows exactly how memory depth affects sample rate at different time base settings. Deep memory has two effects as the scope's time base is slowed down: it delays the onset of the sample rate reduction, and it reduces the extent of the sample rate reduction once it does occur. The result is significant. At 100 ms/div, for example, the shallow memory scope can only sample at 10 kSa/s, while the deep memory scope can sample at 5 MSa/s. This translates into a 500-fold improvement in the signal frequencies that can be captured without aliasing.

Mixed analog/digital designs require deep memory

Deep memory scopes are capable of achieving high sample rates and long time capture simultaneously. Why is this important? The answer has to do with the types of signals commonly encountered in today's designs. Many designs contain a mixture of signal types and signal speeds. For example, a circuit used in an automotive or consumer application may contain one or more analog signals operating in the kilo Hertz range, as well as numerous digital signals operating in the Mega Hertz range.

To make a system measurement of slow analog and fast digital signals simultaneously, designers must set the scope to a relatively slow time base setting in order to capture a full period or more of the slower analog signals. Yet they will not want to compromise sample rate because once the waveform has been captured they may want to zoom in so that the faster digital signals can be viewed with good resolution. Because many events do not occur repetitively, the simultaneous capture is critical. Correlating signals in such mixed-signal designs is a key verification task, and it is the *difference* in speeds that drives the need for both long time span and high sample rate, which is to say the need for deep memory.

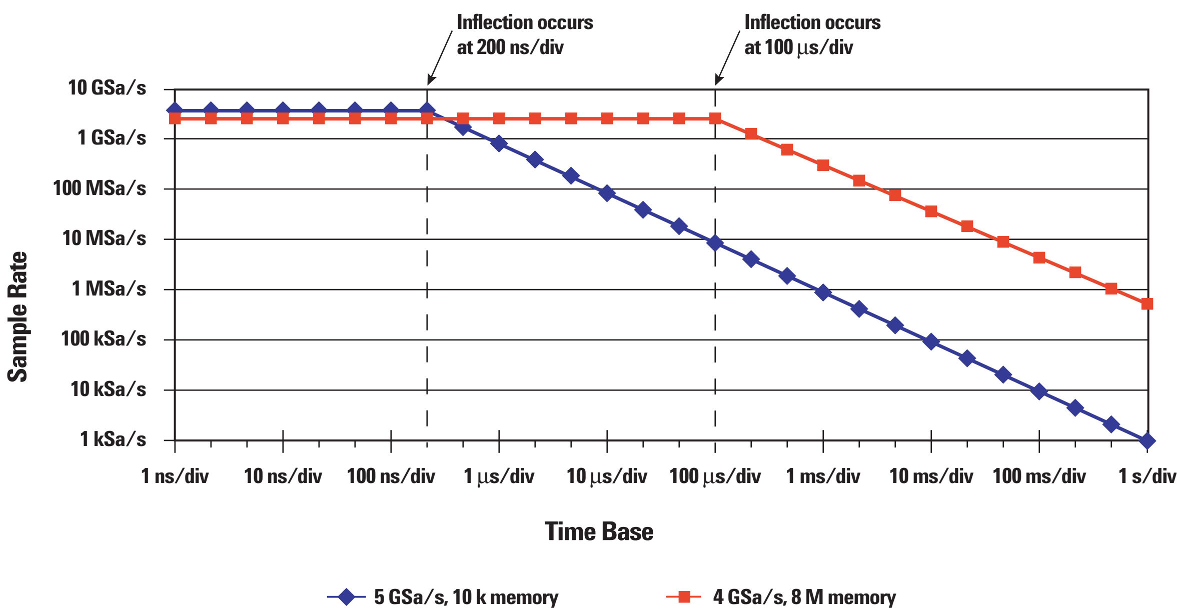

Figure 1. Scope memory affects sample rates.

Displaying the data

Seeing more therefore translates to capturing more details as well as longer time spans. But even here the data capture is only part of the equation. Having acquired all that data, how does a deep memory scope present the digitized samples to the user so that the maximum amount of information about the signal is revealed? This is not a trivial question because depending on the time base setting, thousands or even millions of sample points must be rendered (compressed, really) into each horizontal column of the display.

The Agilent deep memory scopes with MegaZoom III technology use an advanced technique where individual pixels within a display column are illuminated at 256 different intensities based on how many times the corresponding data value occurs. When combined with 1000 columns of horizontal resolution (XGA) and an extremely fast update rate (100,000 real-time waveforms per second), the resulting display looks remarkably similar or superior to an analog scope's display, revealing many subtleties of the signals being measured.

The screen shots in Figure 2 show how the display on a deep memory scope is used to surface an irregularity in the deep capture, and then how the stored waveform is zoomed in by a factor of 2000 to show the details of the glitch. Combining an advanced display system with deep capture, both of which are always on and are not special modes, demonstrates the true power of a deep memory oscilloscope.

Conclusion

Deep memory oscilloscopes are here to stay. Once restricted to advanced users with specialized needs for long time capture, deep memory products are now appreciated more generally for the sample rate and display quality benefits they bring to everyday design and debugging tasks. The primary purpose of all oscilloscopes is to show users what their signals look like, and deep memory scopes truly do let engineers "see more."

To view an on-line video that demonstrates the importance of deep memory, display quality, and waveform update rates, go to **www.agilent.com/find/scope-demo**, and then click on the video titled, "Expanding Beyond Two Dimensions."

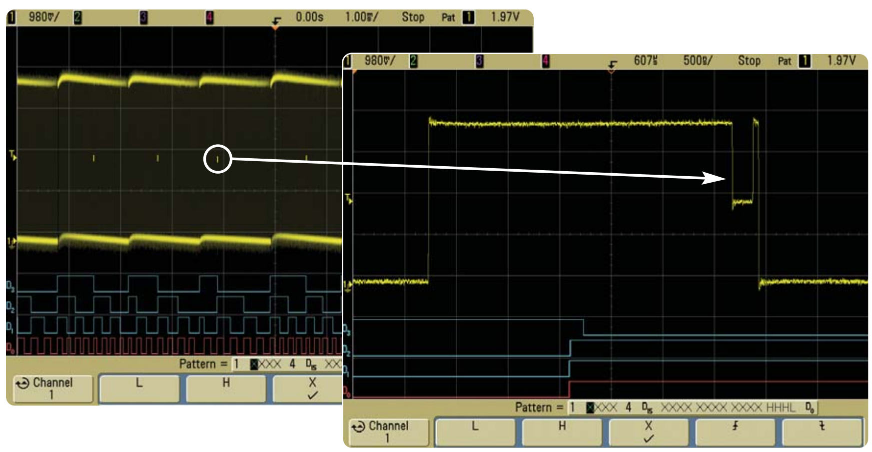

Figure 2. First the display reveals the bright dot – a distortion in 1 of 1,500 pulses – then deep memory allows the user to zoom in for a closer look.

Related Literature

Publication Title	Publication Type	Publication Number
Agilent 6000 Series Oscilloscopes	Data Sheet	5989-2000EN
Improve Your Ability to Capture Elusive Events: Why Oscilloscope Waveform Update Rates are Important	Application Note	5989-2002EN
Oscilloscope Display Quality Impacts Ability to Uncover Signal Anomalies - Agilent 6000 Series Scopes Versus Tek TDS3000	Application Note	5989-2003EN
Oscilloscope Display Quality Impacts Ability to Uncover Signal Anomalies - Agilent 6000 Series Scopes Versus LeCroy WaveSurfer 400	Application Note	5989-2004EN
Ten Things to Consider When Selecting Your Next Oscilloscope	Application Note	5989-0552EN

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