Deep Memory Oscilloscopes: The New Tools of Choice

Application Note 1446

Who should read this document?

This application note is for digital 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 sweep speeds.

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. With prices starting at less than US $3000 and bandwidths running from 60 MHz to 1 GHz and beyond, these scopes are valuable for a wide range of characterization and debug tasks. Why is this the case? Because deep memory scopes let users see more of their signals.

Traditionally the concept of "seeing more" meant observing a device 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 about the time span to be captured.

Suppose the user sets the scope's timebase 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 that 1 ms 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 quite a bit lower than the maximum 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 sweep speeds.

Agilent Technologies

Deep memory means higher sustained sample rate

Deep memory scopes enable the maximum sample rate to be maintained over a much broader range of sweep speeds. For example, the Agilent 54642A digital storage oscilloscope and 54642D mixed signal oscilloscope, which each come with 8 M of memory standard, can maintain their maximum 2 GSa/s single shot sample rate even at the 100 µs/div setting used in the previous example.

The graph in Figure 1 shows exactly how memory affects sample rate at different sweep speeds. Deep memory has two effects as the scope 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 10 MSa/s. This translates into a 1000-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 kHz range, as well as numerous digital signals operating in the MHz range.

To make a system measurement of slow analog and fast digital signals simultaneously, designers must set the scope to a relatively slow sweep speed 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 capture has been made 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.

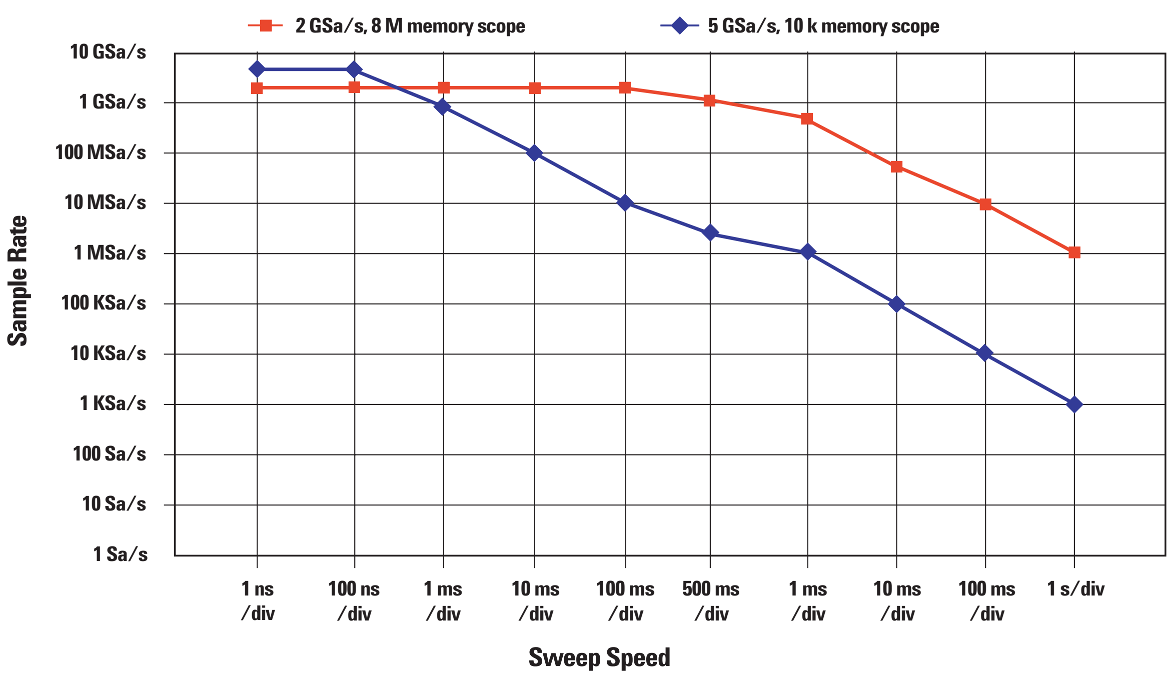

Figure 1. Scope memory affects sample rates.

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 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 sweep speed, hundreds or even thousands of sample points must be rendered (compressed, really) into each horizontal column of the display.

Consider our 100 µs/div example. On a typical scope display with 500 columns, each column will represent 2 µs of time, which corresponds to 4000 samples on a 2 GSa/s scope. Common ways to reduce this data include simple 1-of-N decimation and peak detection; the former is simple, while the latter provides more information to the user about what happened within those 4000 samples.

The Agilent deep memory scopes use an advanced technique where individual pixels within a display column are illuminated at 32 different intensities based on how many times the corresponding data value occurs. When combined with 1000 columns of horizontal resolution and an extremely fast display update rate, the result looks remarkably like an analog scope 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 stopped scope 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 debug 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”.

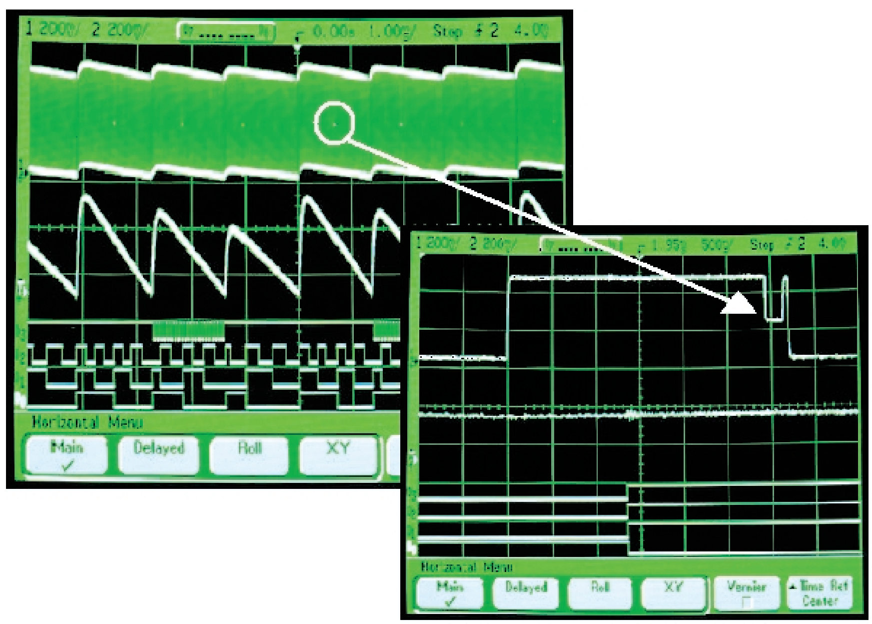

Figure 2. First the display reveals the bright dot — a distortion in 1 of 1,500 pulses — then deep memory allows the user to zoom in for a closer look.

Related Literature

Publication Title	Publication Type	Publication Number
Agilent Technologies Digital and Mixed Signal Oscilloscopes	Selection Guide	5988-8460EN
Finding Hidden Problems Using Agilent's Deep Memory Oscilloscope: How IBM Solved a Mystery	Customer Success Story	5988-5655EN
Mixed Signal Measurement Solution: Which One Fits Your Measurement Needs?	Application Note 1424	5988-8156EN
Capturing Infrequent and Random Events Using Deep Memory Oscilloscopes	Application Note 1431	5988-8240EN
Spectral Analysis Using a Deep Memory Oscilloscope Fast Fourier Transform (FFT)	Application Note 1383-1	5988-4368EN
Debugging a PCI Bus With a Mixed Signal Oscilloscope	Application Note 1417	5988-7745EN
Mixed Analog and Digital Signal Debug and Analysis Using a Mixed Signal Oscilloscope	Application Note 1418	5988-7746EN

Agilent Technologies' Test and Measurement Support, Services, and Assistance
Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise
Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage
Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent T&M Software and Connectivity
Agilent's Test and Measurement software and connectivity products, solutions and developer network allows you to take time out of connecting your instruments to your computer with tools based on PC standards, so you can focus on your tasks, not on your connections. Visit **www.agilent.com/find/connectivity** for more information.

By internet, phone, or fax, get assistance with all your test & measurement needs

Online assistance:
www.agilent.com/find/assist

Phone or Fax
United States:
(tel) 800 452 4844

Canada:
(tel) 877 894 4414
(fax) 905 282 6495

China:
(tel) 800 810 0189
(fax) 800 820 2816

Europe:
(tel) (31 20) 547 2323
(fax) (31 20) 547 2390

Japan:
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Korea:
(tel) (82 2) 2004 5004
(fax) (82 2) 2004 5115

Latin America:
(tel) (305) 269 7500
(fax) (305) 269 7599

Taiwan:
(tel) 0800 047 866
(fax) 0800 286 331

Other Asia Pacific Countries:
(tel) (65) 6375 8100
(fax) (65) 6836 0252
Email: tm_asia@agilent.com

Printed in USA March 25, 2003
5988-9106EN