Demystifying Deep Memory Oscilloscopes

Application Note 1569

Let's start with a simple question. In which of today's technologies is only kBytes (kB) of memory acceptable?

- The RAM capacity of your new 3GHz Pentium D computer?
- The storage capacity of your MP3 player?
- Your oscilloscope?

From the list above, it's pretty easy to point out the areas where more memory is essential.

However, when it comes to item 3 – your oscilloscope – many engineers still believe that only kB of memory is sufficient. No matter your application, an oscilloscope's deep memory – on the order of Megabytes (commonly referred to as Megapoints with oscilloscopes) – provides numerous advantages you'll soon discover are difficult to live without. We'll also examine a couple of common application case studies in which the power of deep memory is clearly revealed.

The Advantages of Deep Memory

Before you consider your next scope purchase, it's important for you to understand exactly why deep memory is so critical. Sample rate, a key specification of every digitizing scope, is not a constant.

Lesson #1
Sample rate ≠ Constant

Sample rate specifications only tell you the maximum sample rate achievable on a scope. In order to determine what your sample rate is, you need to know what memory depth you have available. Given your available memory depth and your typical time base setting, you can then calculate your sample rate.

Lesson #2
Sample rate = Memory depth / Time captured

All digitizing scopes store samples into memory. As memory depth increases, the scope can store more samples into memory. The higher the number of samples that are stored in memory, the higher the sample rate. Thus, deeper memory allows you to sustain the maximum sample rate specified on the scope across a wider range of timebase settings. Keep in mind, too, that due to a higher sustained sample rate, deeper memory will provide you more accurate and reliable measurements.

So now that benefits of deep memory are obvious, where is it used? Turns out, everywhere!

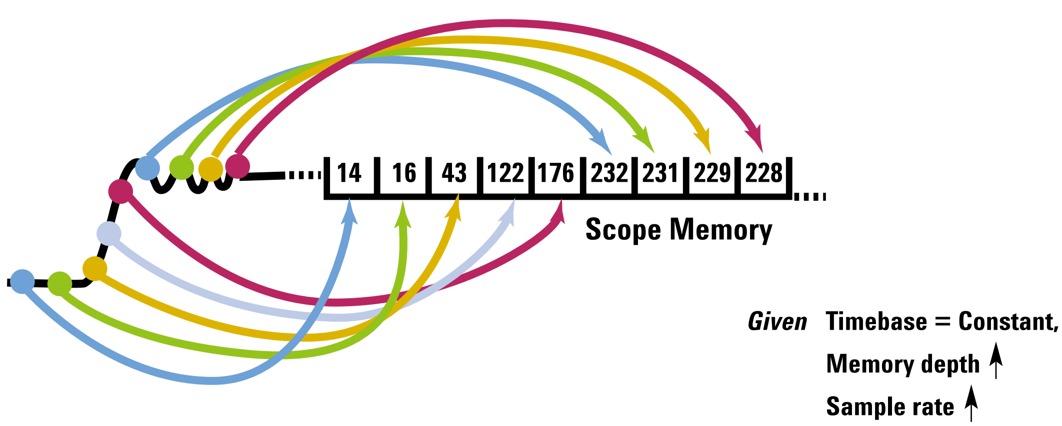

Figure 1.

Embedded Designs

In today's world of mixed-signal and serial-based designs, a common challenge for traditional scope users is how to effectively capture enough cycles of both slow and fast signals simultaneously while maintaining enough resolution to zoom in and see signal details. Without sufficient resolution between points, the scope can't truly tell you what's going on in your design – and, you run the risk of signal aliasing or completely missing events such as glitches or other signal anomalies. Serious problems like these can take hours or even days to discover without the power of a fast deep memory scope at your fingertips. Tack on to that the time it takes to fix the problems and you can quickly run into your already-too-tight schedule slipping.

Serial buses

At the core of most embedded designs today is a either a microcontroller (MCU) or digital signal processor (DSP). Many of these devices have multiple analog, digital, and serial I/O lines that interface to the real world. A common serial bus used in such embedded designs for chip-to-chip communication is I^2C.

In the design example shown here, an I^2C bus connects a MCU to an EEPROM that contains information about sine wave chirps with varying numbers of pulses the MCU is to output via a DAC. In order to verify proper embedded system functionality and isolate potential hardware or software related problems, it's important to correlate the analog output of the DAC to the parallel digital bus output from the MCU to the DAC (Figure 2). By using over 60 Mpts of deep memory, the scope was able to capture with high resolution all sine wave chirps, which are offset in time by a minimum of 5 ms, time-correlated to the faster digital input pulses from the MCU to the DAC. With this single-shot image, you can then zoom in to see a detailed view of one of the slower analog sine wave chirps along with the fast digital I^2C and MCU signals (Figure 3).

A shallower-memory scope would have compromised on sample rate, delivering an incomplete view of the analog and digital interaction in the design.

Figure 2.

Figure 3.

Board turn-on

Turning on a board for the first time can be an interesting experience, to put it mildly! Ideally, all signals would look just right and you'd have confidence that you had covered every corner case during debug. However, when problems occur, the root of the problem rarely jumps out at you. If signals are behaving badly at power up, it can be a mystery as to where to even start looking for cause. In cases like these, a scope's powerful triggering capability often won't come to the rescue – instead, the ability to view a full start-up cycle with high resolution will enable you to trace the path between symptom and root cause. And, the only way to view longer periods of time with full sample rate is to use deep memory.

In this example, the designer used a common memory chip – NVRAM – in his design. With lower-cost NVRAM chips, you often have to worry about the cross-over period from using battery to main power as these chips often do not have built-in circuitry to monitor when full power is applied. However, it is critically important to be able to identify when to switch over from battery to main power. NVRAM has to be in the right state as it powers up or you run the risk of losing data. Because this design incorporated a lower-cost NVRAM chip, an external system reset signal was utilized. The system reset circuit senses very low power, and puts the circuit in reset mode until full power is applied.

At board turn-on, the designer noticed that the NVRAM was losing its data. Without knowing the exact cause of this problem, the designer decided to use a scope to acquire the entire board turn-on cycle – an even that occurred over a period of roughly 500 ms – which would require multiple Megapoints of memory to acquire at high resolution. What was discovered was that the FET gate (pink trace) wasn't supposed to go high. When it did, it prematurely turned the NVRAM to operation mode, which drew operating current (Figure 4).

Because this designer was using a deep memory scope, he was also able to zoom in by a factor of 50 down to 1ms/div, where he detected another problem – a small bump in the system reset signal (green trace, Figure 5)! A series R-C circuit at the gate of the FET resolved this unanticipated problem.

Figure 4.

Figure 5.

Wideband communication
Many people wouldn't think of a scope as the first tool of choice for wireless debug. However, as DSPs and digital circuitry have an increasing presence in today's and tomorrow's wireless designs, engineers are forced to be both RF and digitally-minded. Additionally, wideband designers, in particular, can't use more traditional tools such as spectrum analyzers because of limited analysis bandwidth. Oscilloscopes, such as the Agilent Infiniium scopes, provide the needed bandwidth plus analysis software required to demodulate and analyze wideband and ultra-wideband signals.

Most wireless transmission packets are on the order of milliseconds in length – satellite packets, for example, are each about 4 ms long and can have a span up to 800 MHz. Viewing multiple packets quickly gets you looking at tens of milliseconds of time – and, to sustain high sample rate while viewing the full signal span, deep memory is required.

When analyzing the spectrum of signals such as the satellite communication signals discussed above, deep memory plays a critical role. The frequency resolution is directly related to the amount of time viewed on the screen, with more time providing finer resolution. And, the maximum frequency you can view is directly tied to sample rate – higher sample rate allows you to look at a higher maximum frequency. Capturing and viewing long periods of time at high resolution requires the use of deep memory.

The image to the right is that of a QPSK-modulated signal captured on an Agilent Infiniium scope with deep memory. The vector signal analysis software package can be installed directly on the scope, making it easy to capture, view, and analyze wireless signals. Deep memory, coupled with high sample rate, allowed this designer to capture the full spectrum – in this case, about 300 MHz – of his QPSK-modulated signal with fine resolution. Additionally, the vector signal analysis software allowed him to digitally demodulate his signal and view the spectrum, constellation diagram, actual data bits and error vector magnitude measurement (Figure 6).

Deep memory is for everyday use!
When it comes down to it, deep memory provides you many things you look for in a scope with one in particular: confidence that you are not 'missing something.' By using deep memory, you can be assured of high resolution waveform capture due to a high sustained sample rate; the ability to look at longer periods of time, particularly useful when trying to view both analog and digital signals simultaneously; and, the ability to trace symptom back to root cause when a good trigger event can't be defined. A good deep memory scope can show you things you've been missing and save you time in the process.

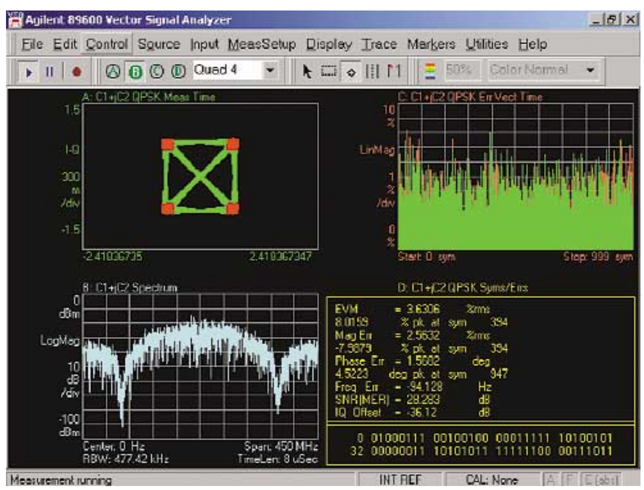

Figure 6.

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