Barring dramatic advances in battery technology, the pressure is on electronic engineers to continually find ways to reduce power consumption while at the same time boosting performance. Since monitoring low frequency events like power supply droop is becoming more critical in the quest for power efficiency, engineers need the ability to acquire and analyze very long time windows with 20 million points or more to identify the source of problems. Similarly long record capture and analysis is required in spread spectrum clocking (SSC) applications used to reduce EMI emissions.

With insufficient high-speed memory depth, it is not possible to capture a full modulation cycle of a typical SSC clock implementation. Long data records are also useful in everyday troubleshooting work and in many serial compliance tests. Power supply fluctuations can cause an embedded clock to slowly drift from its assigned frequency, for example. Such events may only be visible with long-term accumulations of data, often acquired at maximum sample rate.

The latest high-bandwidth digital oscilloscopes offer deep waveform memory configurations – up to 250 million (250M) samples per channel. These instruments can store many repetitions of patterns such as CJPAT and PRBS15-1. Still all oscilloscopes have a finite amount of memory depth, and using higher sample rates fills the instrument’s memory more rapidly and decreases the time window of data acquisition. We will now look at different tools to improve the efficiency of managing and analyzing long time windows and large data acquisitions.

**Using Search to Handle Long Records**

Imagine trying to use the Internet if search engines such as Google and Bing didn’t exist or Web browser features such as Favorites and Links didn’t exist. That is similar to how engineers feel when trying to view long time windows in their oscilloscope. Record length, one of the key specifications of an oscilloscope, is the number of samples it can digitize and store in a single acquisition. The longer the record length, the longer the time window the oscilloscope can capture with high resolution (high sample rate).

The first digital oscilloscopes could capture and store only 500 points, which made it very difficult to acquire all relevant information around the event being investigated. Over the years, oscilloscope vendors have provided longer and longer record lengths to meet market demands for long capture windows with high resolution to the point that even mid-range oscilloscopes either come standard with, or can be optionally upgraded to, multi-mega-point record lengths.

These mega-point record lengths often represent thousands of screens worth of signal activity. While standard record lengths have increased greatly over the years and can now satisfy the vast majority of applications in the marketplace, tools for effectively and efficiently viewing, navigating, and analyzing
long record length acquisitions lagged behind. Now, however, modern oscilloscopes offer a number of tools that facilitate efficient debug and troubleshooting using long records.

One such feature is a dedicated front-panel knob that provides intuitive control of both zooming and panning. Enhancements such as force-feedback help the user determine how fast to pan on the waveform. The farther the knob is turned, the faster the zoom box moves. This feature saves time by eliminating the need to navigate through multiple menus to adjust the zoom view.

Another convenience is dedicated play/pause controls that scroll a captured waveform across the display automatically while the user looks for anomalies or an event of interest. Playback speed and direction is user controllable. Once something interesting on the waveform is identified, a set mark control lets the user leave one or more “bookmarks” on the waveform as shown in Figure 1.

![Playback and mark of captured waveforms.](image)

**Figure 1. Playback and mark of captured waveforms.**

Inspecting an entire acquisition, especially one with millions of points, to find an event can be time-consuming. A fast alternative is to use the oscilloscope’s waveform search which makes it possible to search through a long acquisition based on user-defined criteria. The oscilloscope finds occurrences of the events and highlights them with search marks for easy navigation as shown in Figure 2. Search types typically include edge, pulse width, runt, logic, setup & hold, rise/fall time, and I2C, SPI, CAN and RS-232/422/485/UART packet content. With this information, the oscilloscope’s search function can then provide a results table with precise timing information of the events along with the capability to navigate between events.

The search features often include signal-shape discrimination features which can extend across live channels, stored data and math waveforms. In contrast to hardware trigger systems that detect signal events in real time, search analyzes stored data and can re-process waveforms using different settings to provide additional information. Or search can operate on math waveforms that apply functions such as filtering or spectral analysis.
During most if not all design cycles, engineers will need to perform some level of debug. This could mean isolating a crosstalk issue, discovering sources of excessive jitter or setting up a complex trigger to check for protocol errors. The challenge with debugging is knowing where to start.

In most cases, basic analysis will reveal that tolerance limits have been exceeded. From there, debug tools provide clues as to the sources of failures and can help isolate root cause problems. Here’s where navigation and analysis tools are critical to shedding light on the complex interactions and events that can lead to errors. In order to capture at least one cycle of SSC modulation, the scope should capture at least 30 µs of data. Trend analysis tools then can quickly show engineers how timing parameters change over time including frequency drift, PLL startup transients, or a circuit’s response to power supply changes. With the aid of specialized software, period trend plots can be useful for understanding modulation parameters. Figure 3 shows a triangular SSC modulation where SSC is applied to a 3.0 Gb/s disk drive data signal.

As shown in Figure 4, the eye diagram is one of the most common tools for validating many bits at once. It is easy to set up and provides a real-time indication of voltage and timing related to the bit error rate:
As the eye margins shrink, the bit error rate rises. An eye diagram complemented with other measurements provides the basis for a rigorous debug toolset. For example knowing a design has 300 ps of total jitter doesn’t help much by itself, but jitter decomposition techniques along with debugging software tools can provide insights into where the primary source of the jitter is coming from. Long records allow jitter decomposition algorithms to see low frequency modulation sources like power supply modulation. This is potentially an adjacent lane adding noise into the system from power supply coupling or possibly there is something wrong with the clock distribution system. These sources are illustrated in Figure 5.

Figure 4. Eye diagram analysis provides a quick visual indicator of voltage and timing performance related to bit error rate (BER).

Figure 5 Knowledge of jitter types and sources aids in debug. Common jitter sources include power supply coupling PLL (tracking or overshoot), limited channel bandwidth and reflections (ISI) and driver imbalance (rise/fall time asymmetry).

Let’s look the debug process of a DDR memory system. Identifying read and write bursts is a fundamental requirement of analyzing a memory system based on DDR2, DDR3 or DDR variants technology. The start or the stop of these bursts can be indentified in real time using the oscilloscope’s triggering capabilities. The next step is to check the signal integrity of the major signals (clock, data and strobe). Once these steps have been performed, search and mark can be used to validate the captured waveforms.
Search provides an automated way to mark every occurrence of reads or writes, depending on which one the user selects as illustrated in Figure 6. This search feature marks the entire burst from beginning to end. Each DDR search is marked with a different color in case the user wants to capture both read and write in two different searches on the same acquisition.

![Search - Configure]

*Figure 6. This screen shows the results of read and write searches.*

**Finding Abnormal Events in a Serial Signal**

Designing and debugging complex systems are more challenging than ever due to the increased speeds of serial communication protocols. Small abnormalities that disturb communication circuitry are more prevalent and harder to find and isolate than ever before.

Figure 7 shows a serial communication signal on a performance-class oscilloscope. An encoding error is suspected to be in the signal. The high sample rate and long record length of this oscilloscope enable it to capture a large number of data points over a sufficiently long period of time, improving the probability of identifying elusive abnormalities in the signal. And through the use of a high-speed waveform acquisition mode and segmented memory, the instrument provides visual clues of waveform elements warranting further investigation.

With segmented memory, 1,000 frames of the signal are captured while maintaining a high sample rate as well as suitable time/div and record length settings. The frames can be scrolled through individually; however, this process can be time-consuming and tedious for 1,000 frames. To expedite a comparison of the frames, an overlay of all frames displays occurrences of frequency through color coding. This
allows the user to quickly and visually see frequency abnormalities within a waveform, pinpointing areas for further analysis as highlighted in Figure 8.

Figure 7. A serial communication signal with a suspected encoding error.

Figure 8. Frequency abnormalities highlighted for further analysis.

Debugging Errors with Time Stamps - Intermittent Microprocessor Interrupts
Segmented memory can provide a different type of functionality for digital designers. For example, if a processor system is being infrequently interrupted, it can be difficult to gather timing information with an oscilloscope. If it’s not known when or how frequently an event will occur, there’s no assurance the instrument in normal acquisition mode will capture the necessary information.

Segmented memory provides a good solution in this case. As shown in Figure 9, the active high interrupt strobe is measured to be roughly 100 nanoseconds wide, so the oscilloscope is set to capture 100 frames of 1,250 points. In this example, the shape of the pulse is not of particular interest. Instead, the focus is on the time of the pulses’ rising edges. This is done by comparing the time stamp data at the trigger point. The time stamps of all the frames can be output in tabular form for in-depth analysis.

![Figure 9. Timing measurements between microprocessor interrupts are made using segmented memory.](image)

**Conclusion**

Designing and debugging complex systems are more challenging than ever due to the increased speeds of serial communication protocols. Small abnormalities that disturb communication circuitry are more prevalent and harder to find and isolate than ever before. At the same time, requirements to lower power consumption across the board lead to increases in noise and unpredictable signal anomalies.

One key to discovering anomalies is the ability to correlate high-speed, digital control signals with slower analog signals using an oscilloscope with deep-memory capabilities. However, dealing with very long records with 20 million points or more can be very time consuming. Powerful tools such as zoom, search and mark and trending make this process faster and easier. By segmenting the acquisition memory and providing a trigger and time stamp for each segment, segmented memory optimizes data acquisition and offers smarter usage of limited memory resources.
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