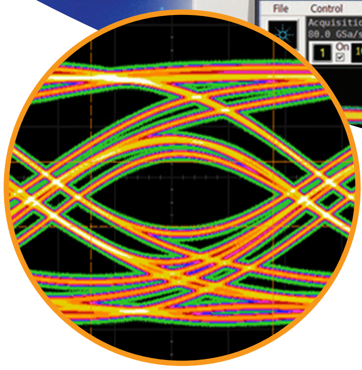
Solutions for

Complex Digital Design

Using a fast, accurate, real-time oscilloscope to maximize design margins

Application Note



Overview

Digital design has become increasingly complex. In part, this stems from the proliferation of third-generation serial busses like USB and SATA. The rise of the PCI Express Base Specification 3.0 (PCIe Gen3) and fourth-generation Serial Attached SCSI (SAS) serial bus, with their respective 8 Gbps and 12 Gbps data rates, further complicates matters. As data rates increase, jitter budgets tighten. These days so much new functionality is being designed into electronic products that design margins are shrinking.

Consider, for example, that for signals running at 10 Gbps, the unit interval (UI) has now shrunk to a mere 100 pS, which does not even include the added jitter of the real-time eye. This may mean a jitter budget of less than 40 pS—less than half that of previous generations. However, in most cases, R&D engineers are forced to leverage the same board material they used in previous designs to avoid additional board design cost. At the same time, they have to design at speeds that are dramatically faster than anything they've designed in before. The result is extremely small design margins.

Problem

The increasing design complexity and shrinking design margins translate into added pressure on today's R&D engineers to accurately predict and validate a design's behavior to ensure it meets specification and avoid costly rework. As a result, the need for a quick and accurate analysis tool has now become all the more acute.

To ensure the highest measurement accuracy, engineers typically will use an equivalent time oscilloscope or a spectrum analyzer (when evaluating jitter). They may also employ a real-time oscilloscope, however in the past it has not been the ideal tool because real-time oscilloscopes add unwanted noise and jitter that often mask a device's true performance. In fact, real-time oscilloscopes have a number of important limitations (e.g., noise floor, jitter measurement floor, and bandwidth) which can erode crucial design margins and, in the worst case scenario, cause devices to fail tests unnecessarily. Typically, companies can ill afford to fail devices due to oscilloscope inaccuracies; however, customers want the flexibility that a real time oscilloscope offers.

Solution

While the answer to this dilemma lies in the use of a real-time oscilloscope, selecting the right oscilloscope is essential. Doing so will prevent devices from failing unnecessarily and, as a result, decrease the time-to-market of key technologies.

There are three key components of an oscilloscope that can impact margins and consequently, affect its measurement accuracy. These components include:

- **Noise Floor.** For margin testing of a digital signal's real-time eye, the oscilloscope's noise floor is one of the most important specifications. Oscilloscope noise erodes eye height and impacts eye width because it erodes rise times and increases the jitter measurement floor. This leads to ghost noise which may impact a device's pass or fail. Accurate measurement, therefore, demands that the oscilloscope have a low noise floor.
- **Jitter Measurement Floor**. Oscilloscopes have an inherent jitter measurement floor (sample clock jitter combined with noise influence due to slew rate) that results in random jitter within the oscilloscope. This specification is influenced by the oscilloscope's noise floor. In general, the slower the rise time (slew rate) being measured, the greater the influence from the noise floor. Obtaining an accurate picture of what a design looks like, as opposed to just looking at oscilloscope noise and jitter, requires the oscilloscope have a low jitter measurement floor.
- **Bandwidth.** To accurately measure an edge, there must be enough bandwidth to give a truthful representation of the edge and ensure that all necessary information has been captured. If the oscilloscope does not have enough bandwidth, the edge will appear much slower than it is in reality. The slower representation of the edge results in jitter substantially higher than its actual value.

Because the signal integrity specifications (noise floor, jitter measurement floor and bandwidth) are so critical to the real-time oscilloscope's measurement accuracy, they can no longer be ignored as insignificant contributors to design margins. Every specification can and will impact margins. Therefore, selecting a real-time oscilloscope that maximizes margins is essential.

One such solution is the Infiniium 90000 X-Series (90000X) high-performance oscilloscope from Agilent Technologies. As the world's fastest real-time oscilloscope, it delivers 32 GHz of true analog bandwidth and features the industry's lowest noise floor, lowest jitter measurement floor, and flattest frequency response (Figure 1). This combination of performance makes the 90000 X-Series the most accurate real-time oscilloscope available on the market.

With 32 GHz of true analog bandwidth performance, the 90000 X-Series oscilloscope has double the analog performance achieved by other commercially available oscilloscopes (16 GHz of pre-amplifier performance). To achieve this performance, many vendors have had to rely on techniques like digital signal processing (DSP) boosting or frequency interleaving. While these techniques allow for higher bandwidth, they cause undesirable tradeoffs. DSP boosting, for example, causes nearly a doubling of oscilloscope noise density. Frequency interleaving can cause significant harmonic distortion and an increase in noise density over the analog hardware performance.

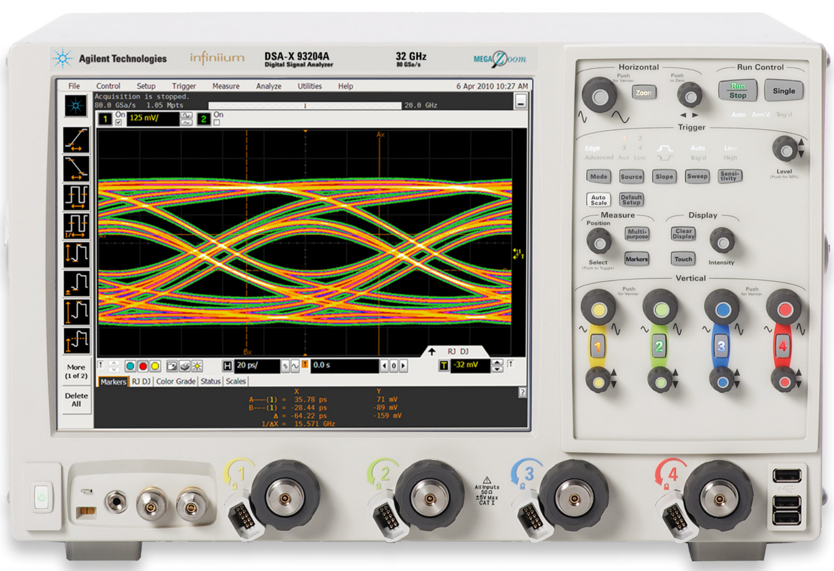


FIGURE 1: *The Infiniium 90000 X-Series oscilloscope has true analog bandwidth to 32 GHz.*

With true analog bandwidth to the full 32 GHz of bandwidth, the 90000 X-Series has significantly less noise and faces no such tradeoffs (Figure 2). Additionally, its sample clock jitter is less than 100 fs. When combined with its low noise floor, this sample clock jitter produces a jitter measurement floor (the actual jitter measured) of less than 150 fs—a mere 1/10th the jitter measurement floor of other comparable oscilloscopes with similar bandwidths. This measurement difference could mean that the 90000 X-Series oscilloscope passes, while other oscilloscopes fail, a device under test. Such capabilities enable the 90000 X-Series to see details that are buried in other oscilloscopes noise.

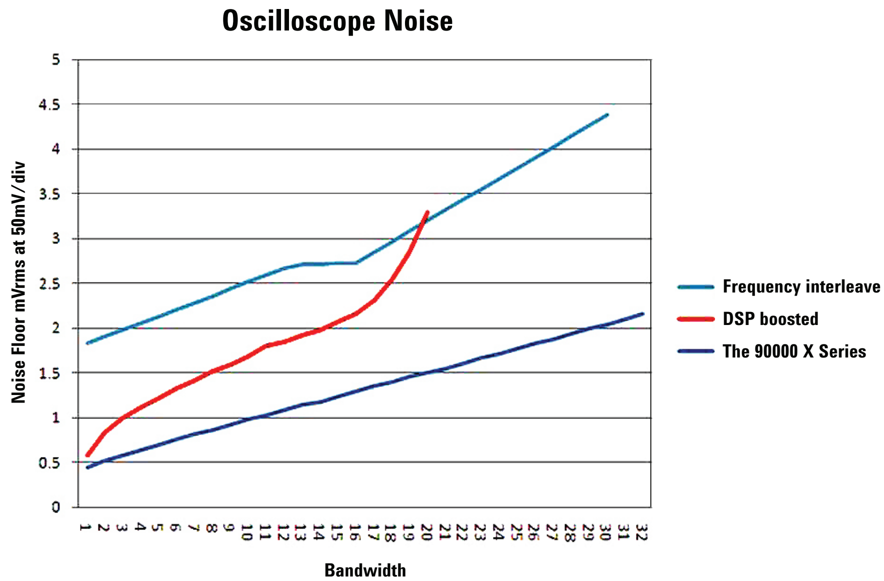


FIGURE 2: *Shown here are noise floor comparisons of different oscilloscopes with different DSP techniques. Note that for the purposes of this graph, the 90000 X-Series uses raw hardware.*

The Value of Software

A fast, real-time oscilloscope with high measurement accuracy is crucial for enabling engineers to make measurements on devices where margins matter. Just as critical though is the ability for engineers to analyze those measurement results. Here, software tools can prove invaluable for helping engineers further their device margins.

The 90000 X-Series oscilloscope comes with the most flexible and accurate, measurement-specific software. The 90000 X-Series can also be combined with Agilent's 89600 Vector Signal Analysis (VSA) software, allowing engineers to easily look at constellation diagrams and diagnose complex modulation (Figure 3). The VSA software supports many signal standards and modulation types to demodulate signal formats such as QPSK, 16 QAM and 64 QAM.

Coupled with the oscilloscope's hardware performance, the 90000 X-Series' probes and software capabilities enable engineers—doing design or debug on a signal of interest—to complete their tasks faster and more accurately than any other oscilloscope on the market. Because the 90000 X-Series also allows engineers to specify tighter specifications, companies can realize greater profitability.

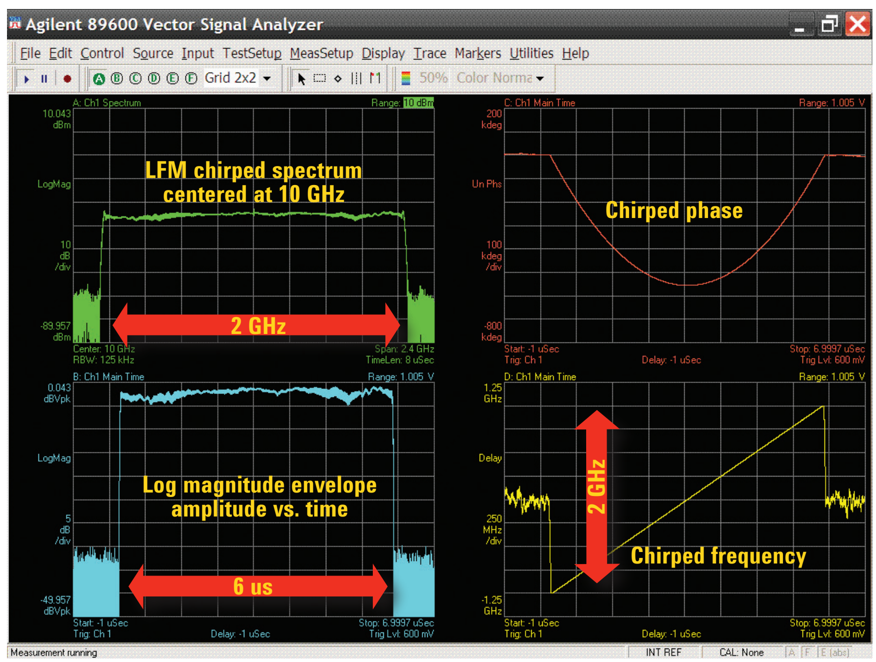


FIGURE 3: *Shown here is a wide-bandwidth LFM chirped Radar measurement using the VSA software on the 90000X oscilloscope.*

Summary of Results

As design complexity increases, design margins will continue to shrink. In this situation, oscilloscopes are often the engineer's instrument of choice to help them understand what's going on inside their devices. When utilizing an oscilloscope for measurements where margins matter, it is critical to choose one that maximizes the margins since the cost of failing devices due to oscilloscope inaccuracies is simply too great. With its low noise floor and jitter measurement floor, the Infiniium 90000 X-Series oscilloscope offers the real-time measurement accuracy today's engineers need to address this challenge. Not only does it make it possible for them to see the details often hidden or buried in the noise of other commercially available oscilloscopes, but its speed can significantly decrease the time-to-market of key technologies as well.

The Power of X

The Agilent Infiniium 90000 X-Series high-performance oscilloscopes are key products in Agilent's comprehensive Power of X suite of test products. These products grant engineers the power to gain greater design insight, speed manufacturing processes, solve tough measurement problems, and get to market ahead of the competition.

Offering the best combination of speed and scalability, and created and supported by renowned worldwide measurement experts, Agilent's X products are helping engineers bring innovative, higher-performing products to emerging markets around the globe.

To learn more about Agilent's suite of X products please visit:
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Related Applications

- Radar and satcom measurements
- LTE MIMO PHY modulation analysis and test
- SAS 12G, PCIe gen3, GDDR5, DisplayPort 1.2, and SATA 6G measurements
- Photon Doppler velocimetry
- RF measurements around the Ka band

Related Agilent Products

- Infiniium 90000 X-Series oscilloscopes (www.agilent.com/find/90000X-series)
- 89600 Vector Signal Analysis (VSA) software (www.agilent.com/find/89600)
- InfiniiMax III probing system (www.agilent.com/find/infiniimax3)

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