Making the Most of Your Infiniium 80000 Series Scope's Acquisition Memory

Application Note 1568

Introduction

Agilent Technologies Infiniium 80000A Series oscilloscopes provide industry-leading signal integrity and probing in conjunction with the industry's widest variety of application-specific software packages. These advantages make the 80000A Series the superior choice for many applications.

Some applications require deep-memory acquisitions from an oscilloscope to achieve the desired measurements. This application note explains techniques that will help you maximize the measurement capabilities of your Infiniium 80000A Series scope's acquisition memory. Using these techniques, you can use the 80000A Series to make a wide array of deep-memory measurements. You will see how the signal integrity, probing and application software of the Agilent system let you make more accurate and repeatable deep-memory measurements, so you can characterize your high-speed designs with confidence.

Table of Contents

Introduction 1

Advantages of Using an Infiniium 80000 Series Scope 2

Making the Most of Your Acquisition Memory 4

Measurement techniques using the 2-Mpoint high-speed memory (up to 40 GSa/s) 4

Basics: Number of UIs, amount of time capture, PRBS size 4

Example 1: Characterizing the spread spectrum clock of a 3-Gbs SATA system 4

Example 2: Low-frequency jitter components 5

Measurement techniques using the 64-Mpoint lower-speed memory (≤ 4 GSa/s) 6

Basics: Amount of time capture, cycles of a 100-MHz ref clock, etc. 6

Example 3: Phase jitter measurements for reference clocks 6

Example 4: Noise measurement on power supplies 8

Example 5: Viewing compliance and training patterns on high-speed serial signals 8

Measurement techniques using repetitive acquisitions 9

Basics: Repetitive vs. single acquisitions 9

Example 6: Low-frequency jitter measurements 9

Example 7: Bounded uncorrelated jitter 10

Example 8: EZJIT Plus arbitrary data mode 11

Measurement techniques using segmented memory 12

Basics: How segmented memory works 12

Example 9: Thirty two 2-Mpoint segments at 40 GSa/s sample rate 12

Example 10: Four thousand 10-kpoint segments at 4 GSa/s sample rate 12

Conclusion 13

Support, Services, and Assistance 15

Agilent Technologies

Advantages of Using an Infiniium 80000 Series Scope

The advanced signal integrity, probing and application software selection of Agilent's Infiniium 80000A Series and InfiniiMax II probing system can help you make better measurements and increase your design margins.

Signal integrity: To help you make accurate and repeatable measurements, the Infiniium 80000A Series scopes and InfiniiMax II probing system provide a variety of signal integrity advantages, including the industry's lowest noise floor, (see figure 2) lowest jitter measurement floor, lowest trigger jitter less than 500 fs rms and flattest frequency response 0.7 ps rms TIE. These foundational capabilities are crucial for achieving accurate and repeatable measurements. Superior signal integrity maximizes your design margins, because you are not wasting any measurement accuracy due to poor noise, jitter or frequency response of the scope or probing system.

You can easily observe the low noise floor of the 80000A Series by disconnecting any signals from the scope and turning on infinite persistence to view the magnitude of the intrinsic scope noise over time. To quantify the magnitude of the noise, use the vertical histogram capability and look at the standard deviation of the histogram for a measurement of the noise in rms volts. You need to use the standard deviation measurement because the peak-to-peak noise may appear larger on higher-throughput oscilloscopes, even though their actual noise floor is lower than that of other oscilloscopes.

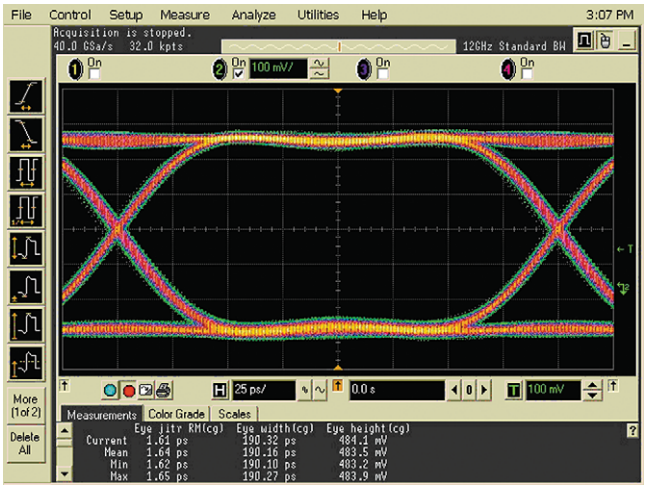

Figure 1. The Infiniium 80000A Series low noise, low jitter, low trigger jitter and flat frequency response produce the industry's most accurate eye diagrams for a real-time scopes.

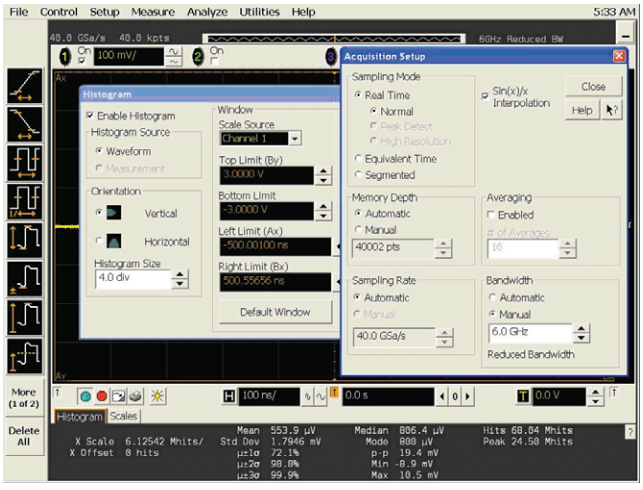

Figure 2. Example of making a noise floor measurement and using the noise reduction capability. Here, we see 1.8 mV rms noise at 100 mV/div and 6 GHz bandwidth, representing the industry's lowest noise floor.

Advantages of Using an Infiniium 80000 Series Scope (continued)

Higher levels of intrinsic scope noise lead to increased measurement errors on every measurement. The primary source of jitter measurement error is voltage noise in the measurement system. Agilent's unique noise reduction capability reduces intrinsic scope noise even further by reducing the scope's bandwidth to the required measurement bandwidth.

The InfiniiMax II Series probe offers you several advantages, as well, including the low noise and flat frequency response mentioned above, which are important for making accurate, repeatable measurements. The InfiniiMax II Series also offers the industry's widest selection of probe amplifier bandwidths (currently six) and the industry's widest variety of different probe head types (currently nine) so that you can match the probe system to your required use models and budget. InfiniiMax II is also the only probing system to offer the full 13 GHz bandwidth for the differential-solder-in, differential-browsing and differential-SMA use models. Since its inception, the award-winning InfiniiMax probe system has provided maximum performance with unmatched usability so that you can be certain that you are measuring your circuit and not your scope probe.

Figure . An InfiniiMax probe amplifier shown with its nine different probe heads

The application software for the Infiniium 80000A Series is the industry's largest – you can choose from 22 application packages that help you tailor the capabilities of the oscilloscope to your specific measurement requirements. Application-specific software solutions include compliance test packages for industry standards such as PCI Express, DDR, FBD, SATA, SAS, FC, DVI, HDMI, USB, FW and Ethernet, as well as more general-purpose jitter and serial data analysis packages. Agilent is also the industry's only vendor to offer innovative packages for ultra-wideband vector signal analysis and noise reduction.

Application software package
E2681A EZJIT jitter analysis (option 002)
N5400A EZJIT Plus jitter analysis (option 004)
E2690B Amherst oscilloscope tools
E2688A SDA high-speed serial data analysis (option 003)
N5391A I^2C/SPI serial data analysis (option 021)
N5402A CAN serial data analysis
N5392A Ethernet compliance (updated)
N5393A PCI Express compliance
N5394A DVI compliance
N5399A HDMI compliance
N5409A Fully buffered DIMM compliance
N5410A Fibre Channel compliance
N5411A SATA I/II compliance
N5412A SAS compliance
N5413A DDR2 clock characterization
N5416A USB compliance (updated)
Fire-Wire compliance (Quantum Parametrics)
89601A Vector signal analysis
N5403A Noise reduction (option 005)
E2625A Communications mask test kit
E2699A My Infiniium integration package (option 006)
E2682A Voice control option

Figure 4. Infiniium 80000A Series application software packages as of November 2005. Additional application packages are being added on a regular basis.

Making the Most of Your Acquisition Memory

Measurement techniques using the 2-Mpoint high-speed memory (up to 40 GSa/s)

Measurement techniques using the 2-Mpoint high-speed memory (up to 40 GSa/s)

Basics: Number of UIs, amount of time capture, PRBS size

The Infiniium 80000A Series offers a maximum memory depth of 2 Mpoints for sample rates up to 40 GSa/s. This results in a time capture window of 50 µs for 40 GSa/s acquisitions and 100 µs for 20 GSa/s acquisitions. This is a significant amount of time for high-speed electronic systems. This time capture window will acquire 250,000 unit intervals of a 5 Gbs signal sampled at 40 GSa/s and 250,000 unit intervals of a 2.5 Gbs signal samples at 20 GSa/s. This is an entire 2^{17}-1 PRBS sequence in a single acquisition. You can easily acquire millions of unit intervals with a few repetitive acquisitions.

Bit rate	Required sample rate	Number of UI captured with 2 Mpts	Max PRBS sequence with 2 Mpts
1 Gbs	10 GSa/s	200,000	2^{17}-1
2.5 Gbs	20 GSa/s	250,000	2^{17}-1
3 Gbs	20 GSa/s	300,000	2^{18}-1
5 Gbs	40 GSa/s	250,000	2^{17}-1
6 Gbs	40 GSa/s	300,000	2^{18}-1
8.5 Gbs	40 GSa/s	425,000	2^{18}-1

Figure 5. Number of unit intervals captured in a single acquisition as a function of the bit rate

Example 1: Characterizing the spread spectrum clock of a 3-Gbs SATA system

This example shows the acquisition and measurements on a full spread spectrum clock cycle of a 3-Gbs SATA signal. Automated Infiniium measurements precisely measure the SSC modulation frequency (33.1 kHz) and the modulation depth (14.3 Mb/s). The SATA SSC modulation frequency of 33 kHz is representative of the SSC frequencies found in many standards. Statistical measurement information can be automatically collected over many acquisition cycles for profiling hundreds of SSC cycles. For systems with high levels of jitter, you also can use cursor-based measurements.

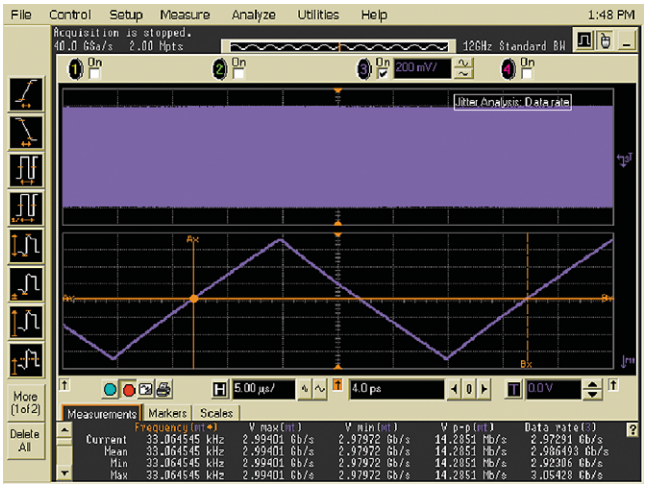

Figure 6. Spread spectrum clock measurements for a 3-Gbs SATA system

Example 2: Low-frequency jitter components

Frequently, engineers want deep memory so they can see low-frequency jitter components. However, PLL clock recovery techniques used in high-speed serial receiver designs reject low-frequency jitter.

For example, the chart shows the jitter transfer function of a first-order PLL with a loop bandwidth of 1.5 MHz. High-frequency jitter is not tracked by the recovered clock and is passed to the measurement. Low-frequency jitter is tracked by the PLL and is removed from the jitter measurement. At 1.5 MHz, the jitter is attenuated 3 dB. At 33 kHz, the jitter is attenuated 13 dB. Deep memory is not required in these measurements because low-frequency jitter is attenuated.

Software clock recovery techniques require some time for the clock to lock to the data. Since the clock is not maintained in hardware, each acquisition requires the clock recovery to sync with the data. Agilent uses five time constants to insure that the clock is locked to the data. So the amount of time it takes for the clock to lock is 5/loop bandwidth. For example, with a 1.5 MHz loop bandwidth, 3.3 µs are required. No jitter measurements are taken during this portion of the acquisition. At 20 GSa sample rate, this will consume 66,666 points. This is a small fraction of the 1 M available, leaving most of the acquisition available for measurement.

If you want to pass all jitter, both low and high frequency, to the jitter measurement, you should use constant-frequency clock recovery. With constant-frequency clock recovery, all jitter is passed. With the 2 M memory that the 80000A Series offers at 40 GSa, one cycle of 20 kHz jitter may be observed. This is below the 33 kHz modulation frequently used for spread spectrum modulation.

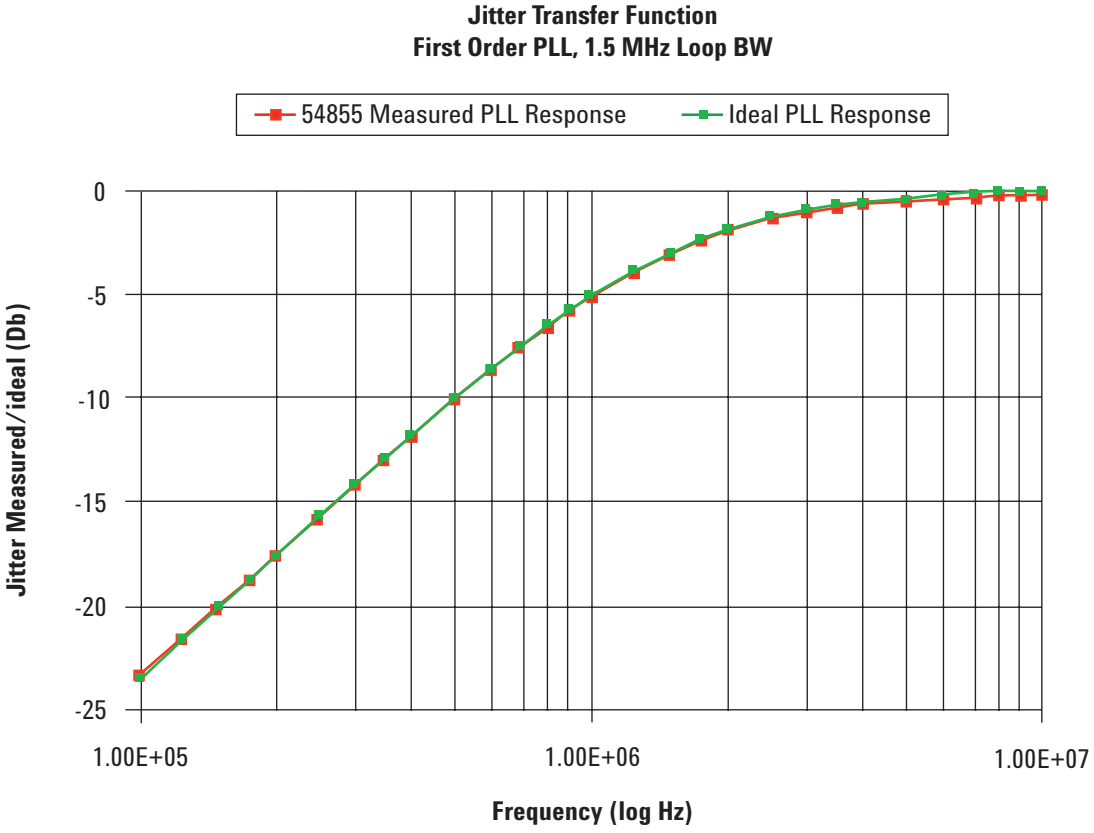

Figure 7. Jitter transfer function of a first-order PLL

Measurement techniques using the 64-Mpoint lower-speed memory (≤ 4 GSa/s)

Basics: Amount of time capture, cycles of a 100-MHz ref clock, etc.

The Infiniium 80000A Series offers a maximum memory depth of 64 Mpoints for sample rates up to 4 GSa/s. This results in a time capture window of 16 ms for 4 GSa/s acquisitions. This is a very large amount of time for mid-speed electronic systems. This time capture window will acquire 1,600,000 cycles of a 100-MHz reference clock sampled at 4 GSa/s and provide frequency resolution to 62.5 Hz.

Example 3: Phase jitter measurements for reference clocks

In this example, we are using the oscilloscope to perform a measurement trend analysis of the period of a PCI Express reference clock running at 100 MHz. In performing a phase jitter measurement of the reference clock, it is important to note that a capacitive *reference load* of 2 pf is applied to the clock. This load creates a first-order low-pass filter with a corner frequency of 1.33 GHz. This filter attenuates high-frequency energy above the Nyquist frequency of 2 GHz, enabling accurate measurements with a 4 GSa/s sample rate. Assuming the PLL input of the reference clock receiver has similar response characteristics to the compliance load, we are able to measure the clock using this reduced sample rate.

Using a sample rate of 4 GSa/s has significant advantages for measuring phase jitter. In PCI Express, for example, it is necessary to measure eye closure due to phase jitter on the reference clock between 1.5 and 22 MHz. The spectral energy represented by this band of jitter is very close to the noise floor of typical real-time oscilloscope instrumentation. The Agilent DSO80000 Series scopes have the lowest noise floor in the industry and when you use only as much sample rate as you need to make the phase jitter measurement, you are able to make more accurate measurements compared to using a faster (and noisier) sample rate.

Making the Most of Your Acquisition Memory (continued)

Measurement techniques using the 64-Mpoint lower-speed memory (≤ 4 GSa/s)

In the example below, we have taken a 13 Mpoint sample of a reference clock giving us a 3 ms measurement window of the clock period trend. By taking an FFT of the measurement trend and then applying the appropriate filter within the frequency domain, we are able to measure the amount of eye closure of the reference clock within the critical 1.5-22 MHz band. For the Agilent PCI Express compliance test software (N5393A) this measurement is performed with software provided by the PCI-SIG. No industry standard compliance test (such as PCI Express, fully buffered DIMM, DDR, SATA, SAS, FC, HDMI, DVI, USB, FW and Ethernet) requires greater memory depth than that offered by the 80000A Series.

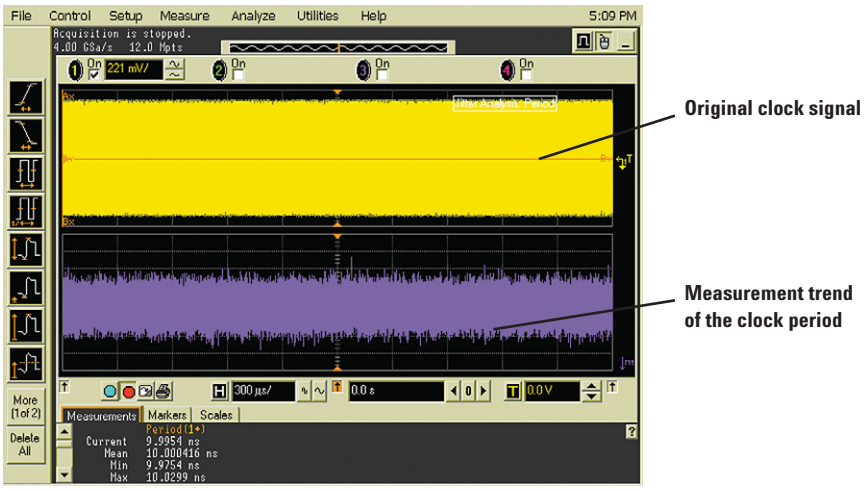

Figure 8. 13 Mpoint sample of a PCI Express reference clock with a measurement trend of the clock period.

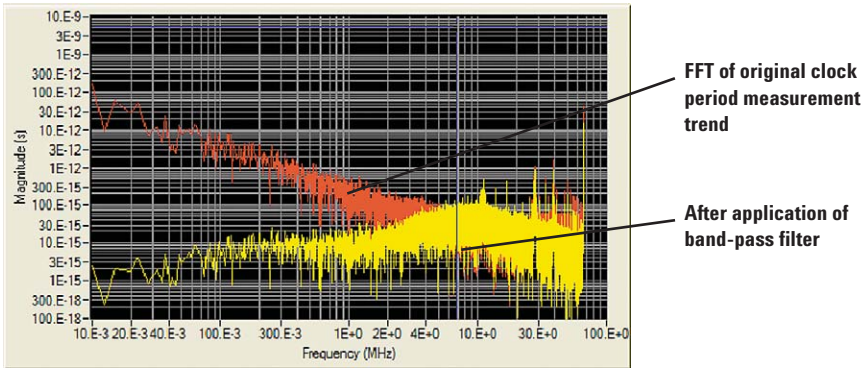

Figure 9. Reference clock measurement as required in the PCI Express reference clock specification

Example 4: Noise measurement on power supplies

In this example, we are looking for noise on a 3.3-V power supply. Power supply noise is typically less than 2 GHz, and therefore you do not need more than 4 GSa/s sample rate to capture it. (If you want, you can verify that there are no higher-frequency components using an FFT at 40 GSa/s). Using a 16.8 Mpoint capture of the signal, we use an FFT to easily identify the switching supply frequency at 135.7 kHz with a resolution of 238 Hz.

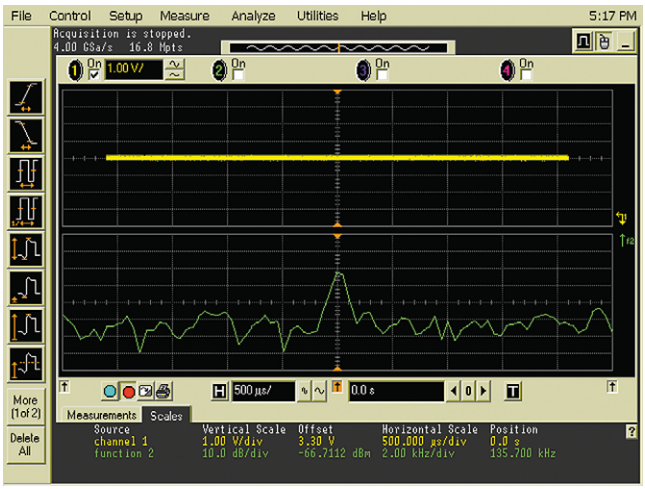

Figure 10. Identifying a 135.7 kHz switching supply frequency

Example 5: Viewing compliance and training patterns on high-speed serial signals

This example shows the acquisition of a 2.5 Gb/s PCI Express compliance pattern. Using a sample rate of 4 GSa/s, we are able to capture more than 2 ms of the signal. The 4 GSa/s is sufficient sample rate to display the decoded compliance pattern symbols (logic level sampling). You can use logic level sampling to capture very long lengths of binary serial data patterns. The higher 40-GSa/s sample rate can be used for signal integrity and parametric measurements.

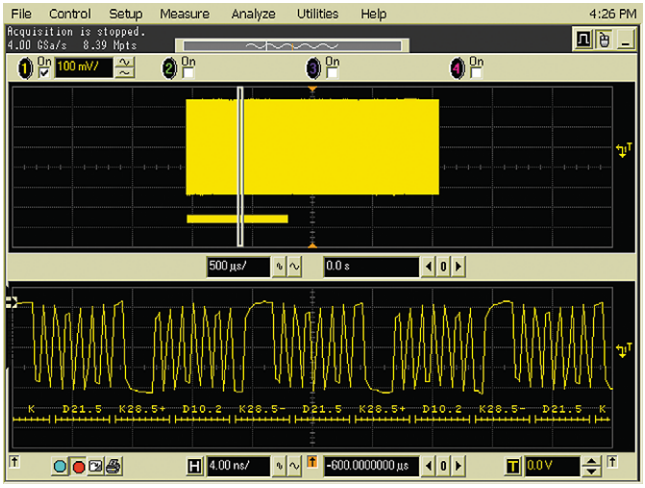

Figure 11. Logic level sampling of a 2.5 Gbs PCI Express signal

Measurement techniques using repetitive acquisitions

Basics: Repetitive vs. single acquisitions

You can use repetitive acquisitions to make many measurements that you might think would require deeper memory. A single, contiguous acquisition is rarely required. If you have a measurement that you believe requires a single long acquisition, consider if the measurement could be made more effectively using multiple shorter acquisitions. Most deep-memory measurements are inherently statistical in nature; they are made on events that occur many times within the acquisition memory record. In these cases, repetitive acquisitions can quickly generate millions of measurements on the event of interest and the measurement will be as statistically valid as if it was taken in a single contiguous acquisition record. Lower-noise oscilloscope and probing systems such as Agilent's 80000A Series and InfiniiMax probes will actually provide superior measurement results for such statistical measurements.

Example 6: Low-frequency jitter measurements

Jitter is always measured relative to a specific time reference that is determined by the clock recovery (CR) method chosen for the measurement. Constant frequency clock recovery, for example, measures jitter relative to the oscilloscope's internal time base reference. The CR method is acceptable for short to moderate waveform acquisition record lengths, but is not acceptable for long waveform record lengths because the long-term phase instability of the transmitter's clock reference or oscilloscope's internal time base can corrupt the measurement results. You can eliminate long-term phase instability errors using one of the various software phase-locked loop (PLL) clock recovery methods provided in the EZJIT Plus jitter analysis application. PLL clock recovery is commonly used because it exhibits a high-pass filtering effect on the measured jitter, duplicating the high-pass filtering effect of the physical CR circuit designed to receive the data signal under test.

Sometimes, however it is desirable to measure the very-low-frequency jitter caused by power supply noise or clock phase instability that would be filtered out by the constant-frequency or PLL clock recovery methods. Figure 12 shows a low-frequency jitter measurement using the EZJIT Plus explicit clock recovery method. The explicit clock recovery method measures the jitter between two input signals. In this case, one is a known stable reference clock and the other is the 1.0625 GHz clock signal under test. In this example, we used EZJIT Plus software to measure known injected 60-Hz sinusoidal periodic jitter (PJdd) of 23.81 ps on the clock signal under test using multiple acquisitions. The multiple acquisitions allow the scope to capture various sections of the very low frequency jitter overtime.

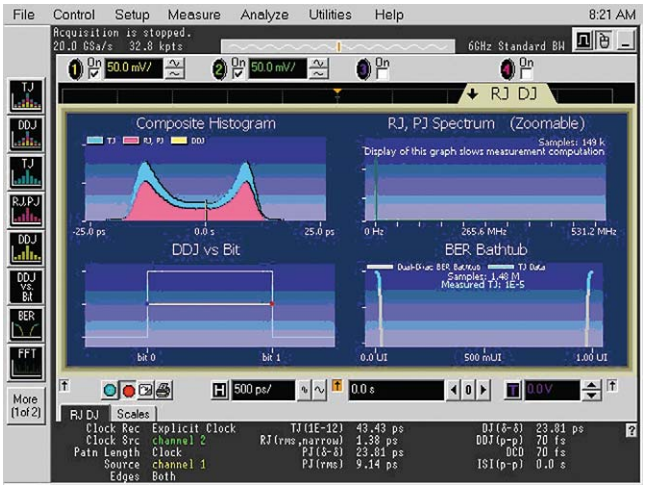

Figure 12. Low frequency jitter measurement using EZJIT Plus

Example 7: Bounded uncorrelated jitter

Bounded-uncorrelated jitter (BUJ) is a type of jitter that is not correlated to the transmitted data pattern, nor is it periodic in time. However, its probability density function (histogram) is non-Gaussian and bounded in width. BUJ events commonly occur infrequently in time. For these reasons, this type of jitter is difficult to measure using any jitter measurement method that extrapolates total jitter from a small sample of the waveform under test. The EZJIT Plus measurement algorithm was specifically designed to include the contributions of infrequent BUJ in its measurement results. Unlike competing jitter measurement algorithms, EZJIT Plus's ability to measure BUJ is limited only by the accumulated number of waveform transitions it analyzes. It is not limited by the number of waveform transitions contained in each individual acquisition.

Figures13 and 14 show two BER bathtub measurements of the same 3.125 Gb/s PRBS signal, which contains about 37 ps of BUJ. Both graphs were measured using the same configuration of EZJIT Plus. However the first one was calculated from a single waveform acquisition and the second one was allowed to accumulate the jitter information from multiple acquisitions. EZJIT Plus represents the directly measured portion of the graph with a blue trace and represents the extrapolated portion of the graph with a white trace. Note that the BUJ is not recognized by the analysis of a single acquisition, causing the TJ (total jitter) results to be grossly underestimated. The analysis of multiple acquisitions however, exposes the BUJ and provides a much more accurate measurement of TJ.

Jitter measurements are inherently statistical in nature. No amount of deep memory will be able to directly measure jitter to $10e^{-12}$ bit error rate (BER). Only a bit error rate tester (BERT) can accomplish this. Real-time scopes can measure the quantity of jitter in the acquisitions they can gather. Real-time scopes can also estimate jitter at low BER by examining the nature of the jitter and applying these to industry recognized BER projection models. The more transitions you can measure, the higher your confidence will be in the accuracy of the jitter measurements. This is true either for direct measurement or for jitter estimation. Because jitter measurements are statistical, the rate of transitions you can measure is important, not the memory depth.

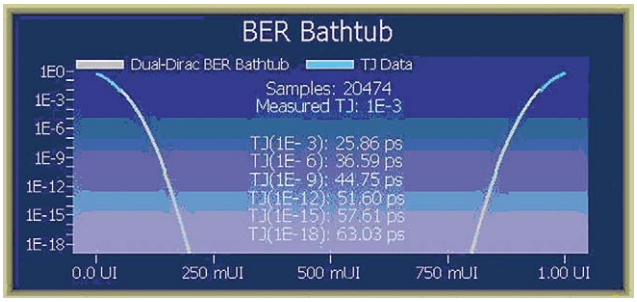

Figure 13. BER bathtub projection using only a single acquisition

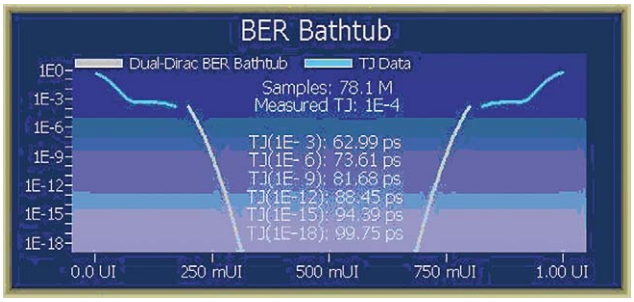

Figure 14. BER bathtub projection with improved accuracy using multiple acquisitions

Example 8: EZJIT Plus arbitrary data mode

The EZJIT Plus jitter analysis application provides two different methods with which to analyze jitter on clock or data signals: periodic data mode and arbitrary data mode. Periodic data mode computes the measurement results very quickly, but requires the input signal's data pattern to be periodic. Periodic data mode is limited to analyzing data patterns that repeat at least 32 times within a single waveform acquisition record. Arbitrary data mode analyzes jitter on all signals, whether the data pattern is periodic or not. Arbitrary data mode enables jitter measurements on "live" transmission data or periodic test patterns that have pattern lengths that exceed the periodic mode requirement of 32 patterns per acquisition. Both the periodic data mode and the arbitrary data mode accumulate jitter information from multiple acquisitions, so the jitter results will contain contributions from all positions within very long data patterns.

Figure 15 shows the results of an EZJIT Plus jitter measurement performed on a 2^{31}-1 PRBS data pattern using arbitrary data mode. EZJIT Plus arbitrary data mode uses a linear regression technique to determine how the ISI jitter at each bit transition is affected by the bit transitions that surround it (ISI filter).

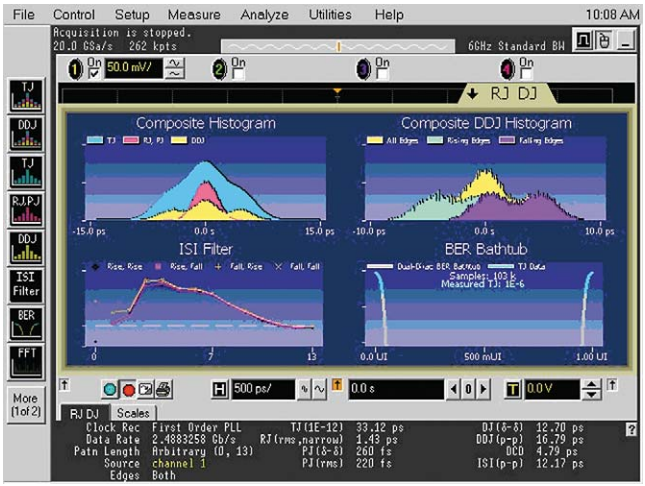

Figure 15. EZJIT Plus jitter measurement performed on a 2^31-1 PRBS data pattern using arbitrary data mode

Measurement techniques using segmented memory

Basics: How segmented memory works

The segmented memory mode allows the user to divide the acquisition memory into a certain number of segments at a given memory depth. In addition, for the Infiniium 80000A Series scopes, the segmented memory mode allows acquisitions captured in the 2-M high-speed memory to be quickly transferred to the 64-M low-speed memory with minimal dead time between acquisitions. Segmented memory is ideal for bursty data signals. Segmented memory can be used to acquire signal regions of interest while ignoring uninteresting regions.

Example 9: Thirty two 2-Mpoint segments at 40 GSa/s sample rate

In this example, we have acquired 2-M segments at 40 GSa/s in the high-speed acquisition memory and transferred them with relatively low dead time (4 ms as shown below) to the 64 M of low-speed acquisition memory. Hence 32 segments can be captured in a rapid fashion. Segmented memory is not intended for use with jitter analysis – multiple acquisitions can be used instead as noted in a previous example. Segmented memory is intended for systems with bursts of signal activity. You can perform functions and measurements on the segments, and the segments can be played repetitively and saved to memory.

Example 10: Four thousand 10-kpoint segments at 4 GSa/s sample rate

In this example, smaller signal segments (10 kpts) are saved directly to the lower-speed acquisition memory. Two thousand segments are stored for a total capture of 20 Mpts. The delay time between segment capture is 22 µs in this example due to the smaller signal segments. The ability to individually set sample rate, segment depth and number of segments provides a great deal of flexibility in configuring the scope acquisition for a variety of systems with bursts of signal activity.

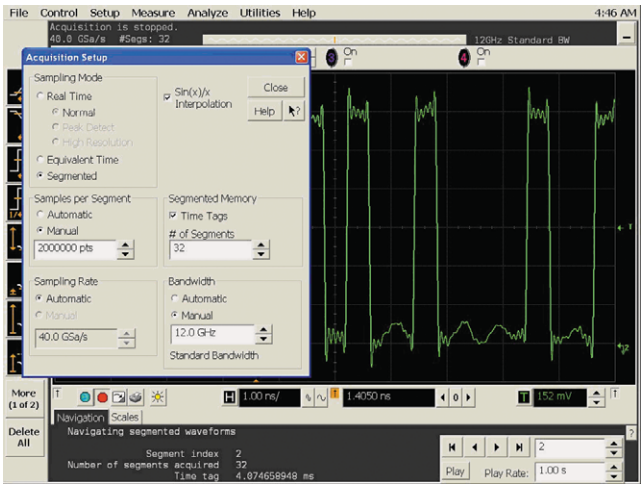

Figure 16. Segmented memory example with thirty-two 2 Mpoint segments and a dead time between segments of 4 ms

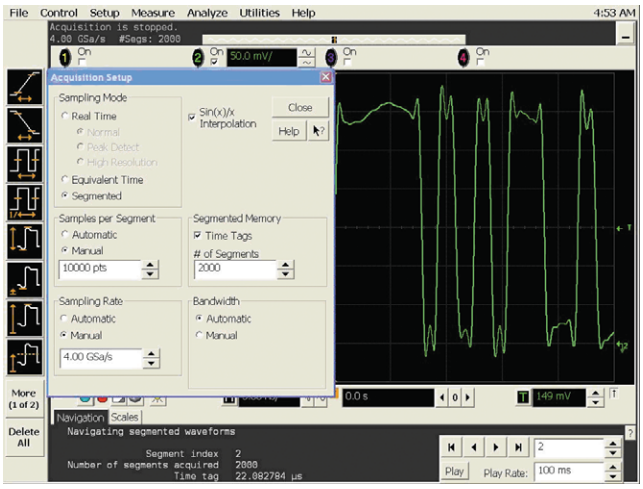

Figure 17. Segmented memory example with two thousand 10 kpoint segments and a dead time between segments of 22 µs

Conclusion

Agilent's superior signal integrity, probing and extensive application software will improve every measurement. For measurements that require deep acquisition memory, this application note has shown how the Agilent Infiniium 80000A Series can make a wide array of deep-memory measurements via the described measurement techniques. The key points:

- The Infiniium 80000A Series scopes' 2 Mpoints of high-speed memory (up to 40 GSa/s) provides sufficient capability for the vast majority of applications. No industry standard compliance test (such as PCI Express, fully buffered DIMM, DDR, SATA, SAS, FC, HDMI, DVI, USB, FW and Ethernet) requires greater memory depth than that offered by the 80000A Series.

- The Infiniium 80000A Series scopes' 64 Mpoints of low-speed memory (≤ 4 GSa/s) can be used for signals up to 2 GHz in bandwidth and provides a time capture window of 16 ms at 4 GSa/s. This provides excellent frequency resolution for signals such as reference clocks. In addition, you can use logic level sampling to extend the capabilities of the low-speed memory mode.

- A single, contiguous acquisition is rarely required for measurements. Repetitive acquisitions can be used to improve the accuracy of jitter measurements and characterization measurements that require measurement statistics. Sixteen 2-M acquisitions taken on a low-noise oscilloscope and probing system will deliver better results than one 32-M acquisition taken on a noisier oscilloscope and probing system. You can use repetitive acquisitions to make many measurements that initially appear to require deeper memory.

- You can use segmented memory to capture the most crucial regions of signal activity without capturing less interesting or idle signal regions. As an example, segmented memory can be used to acquire 32 2-M acquisitions at up to 40 GSa/s with very low dead time between acquisitions. This capability can be important for measuring systems with bursts of signal activity.

If you have a measurement problem that you believe requires deeper acquisition memory than that offered in the Infiniium 80000 Series, please discuss the measurement with your Agilent application engineer. Acquiring more acquisition memory than you need can be expensive and time consuming. Agilent engineers may be able to suggest an alternative measurement technique that uses less acquisition memory that will give you the measurement capability you need.

Related Literature

Publication Title	Publication Type	Publication Number
Infiniium 54850 Series Oscilloscopes	Data Sheet	5988-7976EN
Infiniium 54830 Series Oscilloscopes	Data Sheet	5988-3788EN
N5400 EZJIT Plus Jitter Analysis Software	Data Sheet	5989-0109EN
E2681A EZJIT Jitter Analysis Software	Data Sheet	5989-0109EN
E2690B Advanced Time Interval & Jitter Analysis Software	Data Sheet	5989-3525EN
E2688A High-Speed Serial Data Analysis Software	Data Sheet	5989-0108EN
N5391A I^2C and SPI Analysis Software	Data Sheet	5989-1250EN
N5402A CAN Analysis Software	Data Sheet	5989-3632EN
89601A Vector Signal Analysis Software	Data Sheet	5989-0947EN
N5392A Ethernet Compliance Test Package	Data Sheet	5989-1527EN
N5393A PCI-Express Test Package	Data Sheet	5989-1240EN
N5394A DVI Compliance Test Software	Data Sheet	5989-1526EN
N5399A HDMI Compliance Test Software	Data Sheet	5989-3047EN
N5409A FBD Compliance Test Software	Data Sheet	5989-4128EN
N5410A Fibre Channel Compliance	Data Sheet	5989-4209EN
N5411A SATA Compliance Test Software	Data Sheet	5989-3662EN
N5412A SAS Compliance Test Software	Data Sheet	5989-4208EN
N5413A DDR2 Clock Characterization	Data Sheet	5989-3195EN
N5416A USB Compliance Test Software	Data Sheet	5989-4044EN
E2699A My Infiniium Integration Package	Data Sheet	5988-9934EN
Using Agilent InfiniiMax Probes with Test Equipment other than Agilent Infiniium Oscilloscopes	Configuration Guide	5989-1869EN
Infiniium 54800 Series Oscilloscope Probes, Accessories and Options	Selection Guide	5968-7141EUS

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. 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 receive your new Agilent equipment, we can help verify that it works properly and help with initial product operation.

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 Open

www.agilent.com/find/open
Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

Agilent Email Updates

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

Agilent Direct

www.agilent.com/find/agilentdirect
Quickly choose and use your test equipment solutions with confidence.

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Phone or Fax
United States:
(tel) 800 829 4444
(fax) 800 829 4433

Canada:
(tel) 877 894 4414
(fax) 800 746 4866

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

Europe:
(tel) 31 20 547 2111

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

Korea:
(tel) (080) 769 0800
(fax) (080) 769 0900

Latin America:
(tel) (305) 269 7500

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

Other Asia Pacific Countries:
(tel) (65) 6375 8100
(fax) (65) 6755 0042
Email: tm_ap@agilent.com
Contacts revised: 05/27/05

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2005
Printed in USA, November 15, 2005

5989-4198EN

Agilent Technologies