Keysight Technologies
Jitter Solutions for Telecom, Enterprise, and Digital Designs

Complete solutions for characterization and test of jitter in high-speed digital transmission systems, high-speed I/O connections, and buses
Overview

The measurement of jitter is a necessity for ensuring error free digital communication. As data rates climb, new standards appear, and development cycles shrink, you need the tools that help you keep pace with this changing environment. Keysight Technologies, Inc. provides a wide range of solutions for the injection, prediction, characterization, and testing of jitter.

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<th>Telecom</th>
<th>Enterprise</th>
<th>High Speed I/O</th>
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<td><strong>Definition</strong></td>
<td>Metro/Long Distance Network Traffic. Voice/Data Backbone.</td>
<td>Up to 10 Km Point to Point VOIP/TCP-IP. Building, Site, Campus.</td>
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<tr>
<td><strong>Technologies</strong></td>
<td>SONET, SDH, OTN. OC-48/192/768, STM-16/64/192, OTU-1/2/3.</td>
<td>100M, 1Gbe (Copper), 10Gbe (Optical), 3.125G XAUI electrical.</td>
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<td><strong>Measurements</strong></td>
<td>Unit Interval (UI) vs. Freq. “Sinusoidal” Test with Jitter Analyzers.</td>
<td>Stressed Eye, Transmitter Dispersion Penalty (TDP). “Worst Case Statistical” Test with BERTs and DCA.</td>
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Figure 1. Industry views of jitter

Different market segments from telecommunications to high-speed I/O connections for data communications use the term jitter (see Figure 1). In telecommunications and enterprise arenas, jitter specifications and measurements are well documented through standards bodies, so the measurements to make are well known. In the high-speed I/O arena, many new bus standards are being introduced with little commonality in specifying and measuring jitter. This forces the designer and test engineer to really understand the different jitter measurement viewpoints and what measurement techniques will be best for them.

This brochure concentrates on the jitter measurements required by many of today’s high-speed digital transmission system, bus and interconnect standards – SONET/SDH/OTN, Ethernet, InfiniBand, PCI Express®, SATA, HDMI, etc.
Keysight provides a wide range of jitter measurement solutions (see Figure 2). For SONET/SDH/OTN and electrical/optical jitter measurements, the Keysight 86100C DCA-J is ideal in R&D for components, while the Keysight ParBERT 81250 is ideal for systems.

For electrical jitter measurements, the real time oscilloscope, the Keysight 90000 Series Infiniium with jitter analysis software, provides the most versatile view of jitter with transient capture. The equivalent-time oscilloscope, the Keysight 86100C Infiniium DCA-J, provides the most accurate, sensitive jitter analysis capability and can be a more economical solution. When you need bit error ratio (BER) measurements, the Keysight ParBERT 81250 and J-BERT N4903A construct precise bathtub curves and are the ultimate proof of performance. When a precision, low jitter stimulus is required, Keysight’s J-BERT N4903A offers calibrated jitter levels.

Figure 2. Keysight’s jitter solutions and measurement viewpoints
SONET/SDH/OTN Jitter Measurements

Jitter is defined as the misalignment of the significant edges of a digital signal from their ideal positions in time. Such misalignment, if uncontrolled, can lead to errors in digital transmission. Jitter can also be thought of as an unwanted phase modulation of a digital signal. The term jitter is applied where the frequency band of the unwanted phase modulation is above 10 Hz. Where the frequency band is less than 10 Hz, the modulation is referred to as wander. Even within the jitter bandwidth, international SONET/SDH/OTN standards further band-limit the spectrum when verifying compliance. Different filter values are used for different data rates. For example, for 10 Gb/s SONET/SDH signals, filters rejecting jitter components below 20 Hz and above 80 MHz are used. A further filter is also used to measure only those frequencies above 4 MHz.

The international SONET/SDH/OTN standards specify measuring jitter generation, jitter transfer, and jitter tolerance in the control of jitter. The following pages review these measurements and highlight Keysight’s key solutions for this space – the Keysight 86100C Infiniium DCA-J and J-BERT N4903A.

Jitter generation

Jitter generation, sometimes called intrinsic jitter, refers to the jitter present on the output of a single device (output jitter refers to that from the network). It is specified in unit intervals and the result as a RMS or peak-to-peak value. Most measurement systems use high-pass and low-pass filters to band limit the spectrum. Output jitter results are strongly influenced by the data being carried. Test results can vary widely between those for a simple repetitive pattern such as 1010, and those for a complex PRBS pattern. It is important that the data being transmitted be defined when measuring and specifying jitter generation. Likewise, it is crucial when measuring jitter generation that the result not be affected by the intrinsic jitter of the measurement system.

Jitter tolerance

In order to ensure that your devices can operate error free in the presence of the worst-case jitter from preceding sections in the network, you need to measure jitter tolerance. A signal is generated with added sinusoidal jitter and applied to the DUT. At each jitter frequency, the amplitude of the jitter is increased until transmission errors are detected. Alternatively, a specified level of input jitter is generated and error-free operation is checked. In the real world, jitter is unlikely to be sinusoidal, but it is easy to generate and gives repeatable results. Jitter tolerance requires a source of sinusoidal jitter and a method to assess BER. Using the built-in calibrated jitter source, the Keysight J-BERT N4903A can measure jitter tolerance on electrical devices (see Figure 3).

![Jitter tolerance plot on J-BERT N4903A](image-url)
SONET/SDH/OTN Jitter Measurements (continued)

Jitter transfer

Jitter transfer is typically used to describe how a clock recovery module or repeater locks and tracks data with different jitter amplitudes. Jitter transfer requirements on clock recovery circuits specify a minimum amount of jitter gain vs. frequency up to a given cut-off frequency, beyond which the jitter must be attenuated. The jitter transfer specification is intended to prevent the buildup of jitter in a network consisting of cascaded regenerators. When measuring jitter transfer, you need to be assured your DUT does not transfer more than the SONET/SDH mandated 0.1 dB of peaking. With the Keysight 86108A Precision Waveform Analyzer or 83496B Clock Recovery Module, the 86100C Infiniium DCA-J can measure the jitter transfer of electrical devices (see Figure 4).

Wander

Wander is the longer-term phase variations ranging from 10-Hz down to micro-Hertz and below. While jitter is normally measured with reference to a clock extracted from the data signal, wander is measured against an external reference clock. The fundamental measurement is Time Interval Error (TIE), the instantaneous time deviation of the clock signal under test relative to the reference source. TIE samples are used to calculate wander results such as MTIE (Maximum TIE) and TDev (Time Deviation).

Figure 4. Jitter transfer measurement on 86100C DCA-J
Enterprise and High-Speed I/O Jitter Measurements

What is jitter?

Jitter is defined as the misalignment of the significant edges in a sequence of data bits from their ideal positions. Misalignments can result in data errors. Tracking these errors over an extended period of time determines the system stability. Jitter can be due to deterministic and random phenomena, also referred to as systematic and nonsystematic respectively.

From a general standpoint, jitter characterization involves a statistical measurement of the relative position variation in the clock or data edges. Serial data communication eliminates the physical and bandwidth limitations of clock and data bus transmission by embedding the clock in the transmitted data. Since the data clock is not transmitted separately, the problem of maintaining the clock and data temporal alignment is eliminated in the data stream. However, other issues become important, such as the minimization of jitter in data transmission, faithful clock extraction from the serial data, and network timing. These problems are manifest because of random and systematic effects.

Random jitter

Random jitter (RJ) is Gaussian in nature and typically results from thermal noise, shot noise, etc. In that RJ is unbounded, it is often characterized through an RMS value. This allows one to assess the probability that the jitter will fall both inside and outside a specified range. When an RMS value is measured, the peak-to-peak RJ value can be estimated through multiplication by a factor dependent upon the desired bit error ratio (BER) probability (see Figure 5). Note that these multipliers are valid for purely random jitter. When DJ is present, the BER margin is reduced by the DJ value. A significant amount of data is required to yield a statistically accurate, high confidence characterization of RJ. As seemingly small amounts of RMS RJ correspond to large peak-to-peak values, precisely assessing the full impact of the jitter is achieved by directly measuring the probability of RJ at the desired low BER’s.

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<td>10^{-15}</td>
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</tr>
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</table>

Figure 5. Converting RMS to peak-to-peak for specific BER

Deterministic jitter

Deterministic jitter (DJ) is due to systematic events and is bounded in amplitude. DJ is composed of periodic jitter (PJ), data dependent jitter (DDJ), duty cycle distortion (DCD), uncorrelated (to the data) bounded jitter, and sub-rate jitter. PJ is typically sinusoidal in nature, while uncorrelated bounded jitter is frequently caused by crosstalk. DDJ includes data smearing components such as Inter Symbol Interference (ISI). ISI is typically due to bandwidth limitations of the system and its magnitude is directly dependent on the data pattern being transmitted. DCD is due to voltage offsets between differential inputs and system rise/fall time imbalances. Deterministic jitter is bounded and therefore measured as a peak-to-peak value.

Total jitter

Total jitter (TJ) is the sum of the peak-to-peak values of deterministic jitter (DJ) and random jitter (RJ). By defining random jitter as an equivalent peak-to-peak value at a given probability, and using the dual-Dirac model, total jitter can always be expressed as a sum without loss of accuracy. Figure 6 illustrates the components of total jitter, each of which presents itself in a different way. It can be difficult to separate deterministic and random jitter from the measurement of total jitter and not all test solutions offer this capability. When characterizing your design, the key to success is to understand what you need to test for and optimizing a solution that works for you.

![Figure 6. The components of jitter](image-url)
Enterprise and High-Speed I/O Jitter Measurements (continued)

What jitter measurement viewpoints should you use?

Given the various jitter components, understanding what you need to measure is critical to understanding what is the best test solution for you. The intent of a jitter compliance measurement is to ensure meeting a certain bit error ratio (BER) performance specification. For low BERs (i.e. 10-12 and lower), empirical tests can be long in time duration to capture enough data to confirm the BER specification conformance with sufficient statistical confidence. For design optimization and troubleshooting, post-processed jitter calculations can quickly provide insight.

The following pages review several different measurement viewpoints for capturing jitter information, the best uses of each of the views and Keysight’s solutions. Three common measurement views – eye diagram, bathtub curve and time interval error (TIE) histogram – provide information on the total jitter. Other measurement views provide insight into the distinct jitter components – measurement vs. time, frequency spectrum, RJ/DJ separation, DJ views, and Phase Noise analysis. It is important to understand how alternate views can provide additional insight.

Eye diagram

An eye diagram is a time overlay of level transitions aligned with respect to a derived, or externally provided timing reference, typically a synchronous clock. For certification and validation this measurement is compared to a standard eye mask depicting the allowed eye opening in time and amplitude. The eye pattern measurement technique relies on a data clock that can be derived or accessed and total jitter that is less than the bit period. The crossing point of the eye can be “smeared” by the trigger circuitry of the oscilloscope, so low trigger jitter is critical.

The eye mask test is generally short in terms of test time. The eye diagram is typically captured for a sufficient amount of time to acquire the full extent of the deterministic jitter, which is typically insufficient to capture the extremes of the random jitter peak-to-peak value. Keysight’s 90000 Series Infiniium 13 GHz bandwidth oscilloscope (see Figure 7) and 86100C Infiniium Digital Communication Analyzer-J (see Figure 8), and J-BERT N4903A provide eye diagram and eye mask capabilities.

![Figure 7. Eye diagram with the 91304A Infiniium 13 GHz oscilloscope](image1)

![Figure 8. Eye diagram with the 86100C Infiniium DCA-J](image2)
Enterprise and High-Speed I/O Jitter Measurements (continued)

Eye diagram (continued)

The eye diagram is useful for certification and validation, development and manufacturing. For development engineers, the eye diagram is the most intuitive measurement. It is easy to set up and provides an immediate view of amplitude versus time. Blatant irregularities are easily identified for further development, however it is hard to precisely determine the cause of DDJ, PJ and DCD with this view alone. In manufacturing, the eye diagram provides a quick measurement for confidence, but it does not completely guarantee jitter performance.

To create a jittered test signal, pair the oscilloscope with a J-BERT N4903A pattern generator to create jittered clock or data signals and control the eye closing over the time axis (see Figure 9). The Keysight J-BERT N4903A provides integrated, calibrated jitter sources to simulate real world or worst-case signals. The ParBERT 81250 source can also be jittered with an external modulation source like the Keysight 33250A function/arbitrary waveform generator for multi-lane device characterization.

Figure 9: Stressed eye generation using the J-BERT N4903A pattern generator
Enterprise and High-Speed I/O Jitter Measurements (continued)

Bathtub curve

Plotting the points on a graph of BER versus sampling location in time results in a curve that resembles the cross section of a bathtub, hence the term bathtub curve (see Figure 10). A bathtub curve can be created either by software extrapolation from voltage over time measurement done by an oscilloscope, or by actually sampling the bits as done by a BERT. Any instrument capable of performing a BER measurement can be used to create a bathtub curve, as long as the sampling point can be varied in time. The Keysight J-BERT N4903A and ParBERT 81250 (see Figure 11) can be used to create the bathtub curve. The Keysight 86100C Infiniium DCA-J and 90000 Series Infiniium oscilloscope with jitter analysis software are able to display an extrapolated bathtub curve (see Figures 20 and 21).

For development engineers, the final proof of performance of a component or subsystem is the direct measurement of BER at optimized timing and threshold levels employing error detection on every transmitted bit. However the speed of the BER measurement is a function of the BER to be measured and the desired statistical confidence factor for the result. Various extrapolation techniques can be used to speed up the BER measurement, one of which is based on the bathtub curve called BERT scan. BERT scan allows data to be taken at several quick BERs (i.e. 10-5, 10-7, and 10-9) by adjusting the sampling point in time, and then extrapolates the jitter at much lower BERs (i.e. 10-12). The ParBERT 81250 and J-BERT N4903A have accelerated extrapolation techniques to measure the bathtub curve, extract RJ and DJ components, and to extrapolate TJ at lower BER levels to reduce test times.

To save time yet retain accuracy, the ParBERT 81250 and J-BERT N4903A now feature a “fast TJ” measurement (see Figure 12). It retrieves not only the amount of TJ for a desired BER, but also the uncertainty of the measurement helping to judge the quality of the result. The fast TJ measurement works on any jitter distribution unlike extrapolation methods. It is based on statistics and probability methods. Instead of comparing bits until the BERT reaches a defined number of bits or a defined number of errors, it compares bits until it can decide with a 95% confidence level whether the actual BER is above or below the desired BER. This significantly speeds up the measurement time with the same confidence levels of the bathtub curve.
Enterprise and High-Speed I/O Jitter Measurements (continued)

Histogram

A histogram is a portrayal of the relative occurrence of measured values. Depending on the actual jitter distribution, the histogram shows deterministic jitter components (time interval error) and spread. This is a key measurement in meeting compliance specifications.

Keysight’s 86100C Infiniium DCA-J (Figure 13) and 90000 Series Infiniium oscilloscope with jitter analysis software (Figure 14) provide a histogram of the time interval error (TIE). The 90000 Series oscilloscope also provides additional insightful parameters in the histogram format – cycle-to-cycle jitter, TIE, rise time, duty cycle, etc. Variations in these parameters offer the development engineer insight to the next level of analysis and troubleshooting. The Keysight J-BERT N4903A and ParBERT 81250 can calculate and display a histogram view from the bathtub curve measurement.

Measurement vs. time

The measurement versus time view supplies an intuitive view of rise time, fall time, duty cycle, or TIE versus time. While waveform spikes in the time domain are indicative of errors, these spikes can be correlated to independent signals by comparing them in the time domain.

The Keysight 90000 Series Infiniium oscilloscope with jitter analysis software (see Figure 15) depicts measurement versus time. Parameters such as rise time, fall time, duty cycle, TIE, and period can be measured this way. Comparing the measurement trend and the actual data/clock signal can provide key insight into your design. For example, by viewing the measurement trend of the data rate vs. time it is possible to measure the long-term frequency and modulation depth of spread spectrum clocking.

Figure 13. Histogram from 86100C Infiniium DCA-J

Figure 14. TIE histogram from 91304A Infiniium 13 GHz oscilloscope

Figure 15. Measurement vs. time plot on the 91304A Infiniium 13 GHz oscilloscope
Frequency spectrum

Any measurement vs. time can also be processed to the frequency domain through an FFT conversion. Viewing the jitter frequency spectrum that results can yield swift conclusions of interfering mechanisms than cannot be readily seen in the time domain. Effects that have periodicity in the time domain result in easily discernable spectral components in the frequency domain.

For development engineers, this perspective provides the highest level of insight into deterministic, periodic, and data dependent jitter mechanisms. Keysight’s 90000 Series oscilloscope with jitter analysis software (see Figure 16) and 86100C DCA-J provide FFT spectrum plots. The 90000 Series oscilloscope and 86100C DCA-J when used with the InfiniiMax probing system, assures that the jitter is a result of the circuit and not resulting from the probes. The Keysight J-BERT 4903A and ParBERT 81250 also offer a spectral decomposition capability (see Figure 17).
Enterprise and High-Speed I/O Jitter Measurements (continued)

Jitter spectrum/Phase noise

Precise jitter analysis of clock or data signals is also possible by combining time-domain waveform measurement techniques with frequency-domain phase-noise measurement techniques. The phase-noise technique allows characterization of ultra low-level jitter components with results displayed in seconds or dBc/Hz. Since clock jitter is propagated throughout your system, better understanding it helps reduce data jitter. The Keysight E5052B SSA-J is optimized for clock signal analysis with femtosecond resolution (see Figure 18). The 86100C DCA-J with the 86108A precision waveform analyzer or 83496B clock recovery module can analyze both clock and data signals (see Figure 19).

RJ/DJ separation

Most standards require the decomposition of total jitter into the constituent components – random jitter (RJ) and deterministic jitter (DJ). This separation can be achieved in two ways: extrapolation from a bathtub curve, or by analysis of the jitter frequency spectrum. Using the bathtub curve jitter model, the graph can be curve-fitted to determine the RJ and DJ values. The low BER slopes of the bathtub curve reflect the RJ content of the signal (see Figure 10, page 9). The displacement of the pure RJ content of the bathtub curve slopes from the ideal signal transition times reflects the DJ content of the signal in the dual-Dirac model. The dual-Dirac model provides two easily measured observables, RJ and DJ, that can be used to calculate TJ at low bit error ratios. It is important to note that while DJ is a model-dependent quantity, the TJ calculated from the model is model independent.

Figure 18. RJ spectrum/Phase noise view of clock signal on E5052B SSA-J

Figure 19. Jitter spectrum/Phase noise view of data signal on 86100C DCA-J
Enterprise and High-Speed I/O Jitter Measurements (continued)

RJ/DJ separation (continued)

In the frequency domain, DJ components such as periodic jitter (PJ), inter symbol interference (ISI) or duty cycle distortion (DCD), appear as distinct spectra and can easily be discerned by the eye or by a search algorithm. RJ is Gaussian in nature and appears as a broad and relatively flat spectrum. These differences are used in separating RJ and DJ in the frequency domain.

For the certification engineer, this view is crucial to proving compliance. For the development engineer, the measurement is a tool to quantify the effects of environmental changes on RJ and DJ to circuit performance. Keysight’s 86100C DCA-J and 90000 Series Infiniium oscilloscope with jitter analysis software can be used to separate RJ and DJ using a similar user interface (see Figures 20 and 21). The ParBERT 81250 and J-BERT N4903A (see Figure 22) separate RJ and DJ via extrapolation from the bathtub curve.

![Figure 20. RJ/DJ Separation view on the 91304A Infiniium 13 GHz oscilloscope](image)

![Figure 21. RJ/DJ separation views on 86100C DCA-J](image)

![Figure 22. Histogram plot and RJ/DJ separation values on J-BERT N4903A and ParBERT 81250](image)
Enterprise and High-Speed I/O Jitter Measurements (continued)

DJ views

Deterministic jitter is composed of periodic jitter (PJ), data dependent jitter (DDJ), duty cycle distortion (DCD) and uncorrelated (to the data) bounded jitter. PJ is asynchronous to the data, DDJ is due to data smearing, while DCD is pulse width distortion. DDJ/ISI and DCD can be identified by repetitively averaging the total jitter versus time measurement. This effectively removes periodic uncorrelated jitter and random jitter components, leaving DDJ and DCD.

Keysight’s 86100C DCA-J and 90000 Series Infiniium oscilloscope with jitter analysis software can be used to analyze the components of DJ using a similar user interface (see Figures 23 and 24). Possible measurements include TJ, RJ, DJ, PJ, DDJ, ISI and DCD. The graphical display illustrates a single measurement or four measurements for a quick assessment such as TJ histogram, DDJ histogram, PJ/RJ histogram, DDJ vs. bit pattern, and bathtub curve.

Figure 23. DJ views on a 91304A Infiniium 13 GHz oscilloscope

Figure 24. DJ views on 86100C DCA-J
How Accurate is Your Jitter Measurement – Comparing Different Jitter Analysis Techniques

Digital jitter accuracy analysis using a precision jitter transmitter

To compare different measurement approaches for jitter in digital systems, Keysight created a jitter transmitter with a complete set of applied jitter levels precisely calibrated, in most cases, to traceable standards. The various Keysight and major vendors jitter analysis solutions were applied a wide variety of signals with known TJ (10–12) and known levels of different types of jitter to determined which analyzers are accurate and why.

Figure 25 depicts the precision jitter transmitter. It was designed to apply a wide range of different levels and combinations of RJ, PJ, ISI, and DCD that result in a large set of TJ values. Measurements were made at a single data rate, 2.5 Gb/s, with a single test pattern, a standard pseudo-random binary sequence of length 2^7 – 1 (PRBS7), a single pair of NRZ logic levels, ±280-mV for a logic ‘1’/’0’, and used a single ended transmission line.

Levels of jitter were chosen that reflect what is common in the field. Low levels corresponded to levels a network element would generate and still pass most standards’ compliance tests. High levels corresponded to either barely passing or not quite passing. ISI was created by inserting different lengths of printed circuit board traces in the transmission path. PJ was created in both sinusoidal and triangle-wave formats to challenge the spectral techniques for measuring RJ.

The configurations were designed so that the solutions should give the same results. For example, they were configured to measure the full jitter-frequency bandwidth. The analyzers were configured using minimal modifications to the default settings and a single configuration was used for all test cases, likely the way that most engineers would use them. Analyzer settings were used where the user manuals indicated it would give the best results and allowed for longer test times to accommodate the manufacturers’ suggestions for increased accuracy.

Measurement time varied from less than ten seconds to over a minute. A summary of the precision jitter transmitter can be found in white papers listed on page 20. The J-BERT N4903A was designed based on this investigation to provide a calibrated jitter source (see Figure 26).
Jitter Measurement Solutions

86100C Infiniium DCA-J Wide-Bandwidth Oscilloscope

View optical and electrical waveforms with bandwidths to 80 GHz electrical and 65 GHz optical. Built-in measurements for high-speed digital communications and module configurations for a test system to match your specific needs. View the true jitter of your device with an ultra-low, intrinsic trigger jitter of less than 100-fs.

Typically used to view an eye diagram, the magnitude of the jitter can be immediately viewed in one simple display. Measure random and deterministic jitter components using the one-button jitter analysis application. The 86100C is an ideal tool for making signal integrity and jitter measurements for FibreChannel, PCI Express II, Fully Buffered DIMM, Ethernet, SONET/SDH/ITN, and other similar high speed signaling standards.

Key features/benefits
- Ultra low instrumentation jitter (< 0.1 ps) combined with ultra low voltage noise (< 0.25 mV) allows precise measurement of extremely low jitter on signals
- Comprehensive waveform characterization is possible
- 50 MHz to 13.5 Gb/s clock recovery capability with 86108A or 83496B with selectable loop BW, and phase noise analysis
- Advanced waveform analysis – built in equalization for closed-eye analysis
- Time domain reflectometer modules available to further characterize high-speed data channels

For more information order the following literature:
86100C Technical Specifications, publication number 5989-0278EN

90000 Series Infiniium 13 GHz Bandwidth Oscilloscope

The Keysight 90000 Series Infiniium oscilloscopes and the InfiniiMax 1160 Series probing system deliver the highest performance real-time end-to-end measurement system available. The Infiniium 90000 Series is an ideal tool for making signal integrity and jitter measurements for PCI Express®, Infiniband, RapidIO, SATA and other similar high speed signaling standards.

Key features/benefits
- 13 GHz, 12 GHz, 8 GHz, 6 GHz, 4 GHz, and 2.5 GHz bandwidth real-time oscilloscopes with 40 GSa/s sample rate on four channels, (20 GSa/s on 6 GHz and lower models)
- Up to 1 Gpts MegaZoom deep memory at all sample rates
- Trigger jitter as low as 1.5 ps RMS and as low as 0.65 ps RMS jitter noise floor for accurate jitter measurements
- The E2690B advanced jitter and timing analysis software offers the most comprehensive set of tools available for in-depth analysis of jitter behavior
- The N5400A EZJIT Plus jitter analysis software offers a similar user interface and proven accurate algorithms as the 86100C DCA-J
- InfiniiMax 12 GHz, 10 GHz, 7 GHz, 5 GHz, and 3.5 GHz probing systems that support differential and single-ended measurements for a more cost-effective solution

For more information order the following literature:
90000 Series Technical Specifications, publication number 5989-7819EN
E2690B Technical Specifications, publication number 5989-3525EN
N5400A Technical Specifications, publication number 5989-0109EN
Jitter Measurement Solutions Continued

81133A/81134A Pulse Pattern and Data Generators

The 81133A, and 81134A are high performance sources for square waves, pulses, data patterns and pseudo random data sequences up to 3.35 GHz. Their hardware PRBS generation, extended pattern memory, and wide-bandwidth jitter insertion capability make them an ideal stimulus for turn-on and validation tests such as stressed eye measurements. The fast rise times and low intrinsic jitter ensure the highest signal integrity and precise timing.

Key features/benefits
- Delay control input (jitter control)
- Direct mode (instrument follows external frequency exactly)
- Clock (including subrates), data and PRBS signals
- Multiple data formats (NRZ, RZ, R1)

For more information order the following literature:
81133/4A Technical Specifications,
publication number 5988-5549EN

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Figure 27: Pulse pattern generator solutions
Jitter Measurement Solutions (continued)

ParBERT 81250

The ParBERT 81250 provides parallel and multi-serial BER testing up to 45 Gb/s for high-speed digital components. The modular design lets you mix and match analyzer channels, generator channels and speed classes (333 kHz to 675 MHz, 333 Mb/s to 1.65 Gb/s or 2.7 Gb/s, 21 Mb/s to 3.35 Gb/s, 150 Mb/s to 7 Gb/s, 150 Mb/s to 13.5 Gb/s and 38 to 45 Gb/s).

The ParBERT 81250 provides the ability to generate jitter (3.35 Gb/s, 7 Gb/s and 13.5 Gb/s modules only) and analyze jitter. The low intrinsic jitter of the 3.35G/7G/13.5 Gb/s receivers enables precision jitter analysis. The 3.35G/7G/13.5 Gb/s generators are capable of stressing the DUT by injecting RJ and DJ with a per channel delay control input (driven by an external modulation signal).

Key features/benefits
- Generate custom patterns, pseudo random word sequences (PRWS) and standard PRBS up to 231 – 1
- Jitter analysis (extract and extrapolation) with bathtub curve and spectral decomposition
- Fast TJ measurement capability
- External delay control input (jitter modulation) on the 3.35G/7G/13.5 Gb/s generators (up to 200 MHz bandwidth with ±250-ps delay range for 3.35-Gb/s, up to 1 GHz with ±100 ps delay range for 7G/13.5 Gb/s)

For more information order the following literature:
Product Overview, publication number 5968-9188E

90000 Series Infiniium 13 GHz Bandwidth Oscilloscope

The J-BERT N4903A is the ideal solution for research, development, and test of digital components; devices and subsystems up to 12.5 Gb/s. It provides complete, calibrated jitter sources for stressed eye testing of receivers. Automated jitter tolerance testing allows quick and accurate compliance and characterization testing. For transmitter analysis, a wide range of jitter analysis tools are built-in and provide insight into the underlying causes behind bit errors.

With this high performance serial pattern generator and error detector, you can perform error analysis to verify the operation and quality of gigabit serial links used in PCI Express®, SATA, Fibre Channel, CEI, XAUI, 10 Gigabit Ethernet and optical XFP/XFI transceivers.

Key features/benefits
- Integrated, calibrated jitter source for PJ, SJ, RJ, BUJ, ISI and sinusoidal interference
- Clean signal generation with fast transition times and low intrinsic jitter
- Total jitter, BER Scan, spectral jitter decomposition, Fast TJ, jitter tolerance, eye mask and eye contour measurement capability
- Integrated CDR with tunable loop bandwidth for compliance measurements

For more information order the following literature:
N4903B Technical Specifications, publication number 5989-2899EN
Jitter Measurement Solutions (continued)

E5052B/E5001A Signal Source Analyzer with Jitter Analysis (SSA-J)

The E5052B Signal Source Analyzer (SSA) when used with the E5001A SSA-J Precision Clock Jitter Analysis software is ideal for analyzing ultra-low level RJ, PJ, and TJ in clocks. Utilizing frequency domain phase-noise measurement techniques, RJ measurements with femto-second resolution are possible.

The E5052B SSA-J allows jitter measurements from 10 MHz to 7 GHz, and is extendable to 26.5 GHz in coax via the E5053A microwave down converter.

Key features/benefits

- Precision clock jitter measurements
- Ultra-low RJ measurement with femto-second resolution
- Real-time jitter spectrum analysis on both RJ and PJ at 1 Hz to 100 MHz offset frequencies from the clock carrier
- Time-domain measurements on jitter trend, histogram, and RJ/PJ separation of clock signals

For more information order the following literature:

E5052B Technical Specifications, publication number 5989-6388EN

E5001A Technical Overview, publication number 5989-5040EN
Related Literature

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Further information on Keysight’s jitter measurement solutions can be found online at www.keysight.com/find/jitter

Have questions about jitter measurements? Consult the Keysight Jitter Master discussion forum online at www.keysight.com/find/jitter_forum
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Published in USA, December 1, 2017
5988-9592EN
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