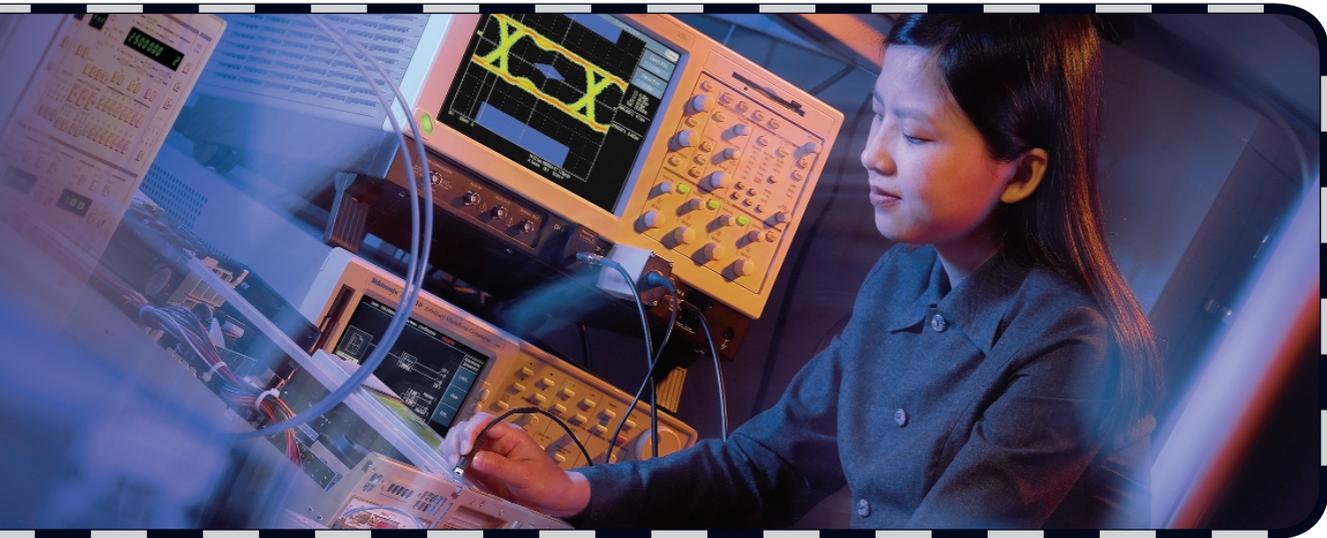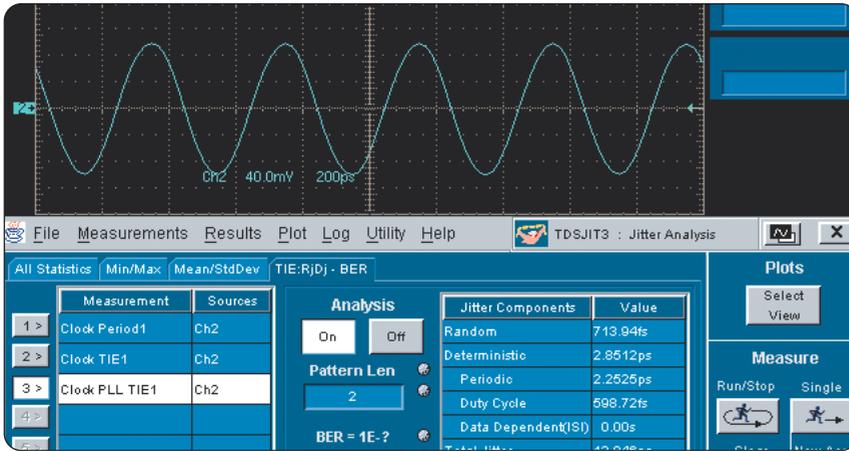# The Most Comprehensive, Convenient and Cost-Effective Answer to Resolving Jitter Issues in Your Designs

## TDSJIT3 Jitter Analysis and Timing Software

**Tektronix**

Enabling Innovation

## Solve Your Toughest Jitter Problems with Powerful, Convenient and Cost-Effective Tools

Jitter is the unintended timing variation in the placement of individual edges in a signal. Characterizing and controlling jitter is essential to the design of high-speed systems that dependably meet performance requirements. As signaling rates climb to keep up with data flow demands and pulse amplitudes shrink to conserve power in today's high speed digital, communication and system designs, jitter-induced errors have become a fundamental limit on product performance. You need to use the most comprehensive set of advanced tools to solve today's challenging jitter problems.

The most powerful jitter analysis solution may already be on your bench. Tektronix high-performance, yet general purpose, oscilloscopes can perform all the essential jitter and timing measurements with the simple addition of an optional application. You can analyze jitter completely within the oscilloscope, often without changing connections to the device under test — a convenient, cost-effective expansion of your test resources.

TDSJIT3 Jitter Analysis Software equips your Tektronix TDS5000, TDS6000 or TDS/CSA7000 Series oscilloscope with the most comprehensive and highest accuracy jitter measurements in the industry. TDSJIT3 provides the full complement of basic jitter measurements plus advanced analysis algorithms to decompose jitter into its random and deterministic components to help you isolate their causes.

## Get to the Root of the Problems, Refine Your Designs

The unique advanced jitter analysis tools in TDSJIT3 let you gain unprecedented insight into the nature and composition of jitter to help you identify sources, isolate problems and predict the performance of your designs. These powerful tools take you beyond the simple measurement of jitter to the solutions you need to optimize your designs.

**Identify the sources of jitter.** Now you can more readily differentiate between the jitter in your design and that caused by other sources. TDSJIT3's advanced feature set contains unique algorithms to separate and quantify jitter components, analyze them and correlate them with potential causes. By focusing on the sources that you can control, you can quickly refine your designs for peak performance.

**Capture intermittent events.** Built-in worst case waveform analysis functions allow you to capture isolated and randomly occurring jitter events that could easily be missed by conventional single-shot acquisitions.

**Predict performance over a range of operating conditions.** The software provides probability and analysis functions that translate jitter measurements into estimates of bit error ratio (BER), more accurately predicting the behavior of designs in a range of conditions.

## Fundamental Jitter Parameters

Jitter is characterized with a number of fundamental measurements. Basic jitter parameters include:

▶ **Period jitter** measures the period of each clock and data in a real-time waveform. This measurement shows the overall quality of a signal. It is similar to and correlates well with older methods like cursor and histogram measurements of period jitter, or measurements made using a time-interval analyzer.

▶ **Cycle-to-cycle jitter** measures how much the clock or data period changes between any two adjacent cycles — found by applying a first-order difference operation to the period jitter. This measurement shows the instantaneous dynamics that a down-stream clock-recovery PLL will encounter. Too large a change might lead to data clocking errors or the PLL losing lock completely.

▶ **Time interval error (TIE)** measures how far each active edge of the clock or data varies from its ideal position, using a reference clock or clock recovery to provide the ideal edges. TIE is especially important in communications systems because it shows the cumulative effect that period jitter has over time.

▶ **Statistics:** All jitter has both random and deterministic components. Because of the random components, jitter is best specified using common statistical techniques. Metrics such as mean value, standard deviation, and peak-to-peak value, with qualifiers such as confidence interval, are used to establish meaningful and repeatable measurement results.

▶ **Eye Diagrams:** The effect of jitter can be seen in the eye diagram, short segments of a waveform that are superimposed to align the nominal edge locations and voltage levels. Once the jitter reaches ±0.5 UI, the eye is closed and a receiver circuit will experience bit errors.

▶ **Clock Recovery** establishes a reference clock from the data signal — a jitter-free clock with the same mean frequency and phase as the measured data. One method of clock recovery generates a constant-frequency clock that best fits the measured data. Another method of clock recovery is with a PLL that constantly tracks slowly-varying changes in the frequency and phase of the measured data.
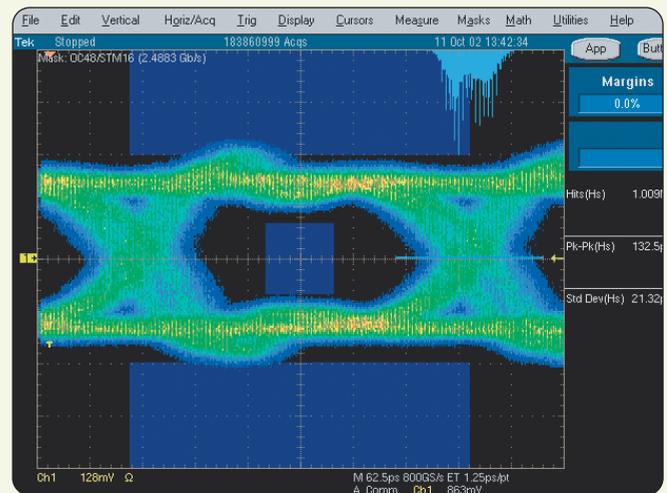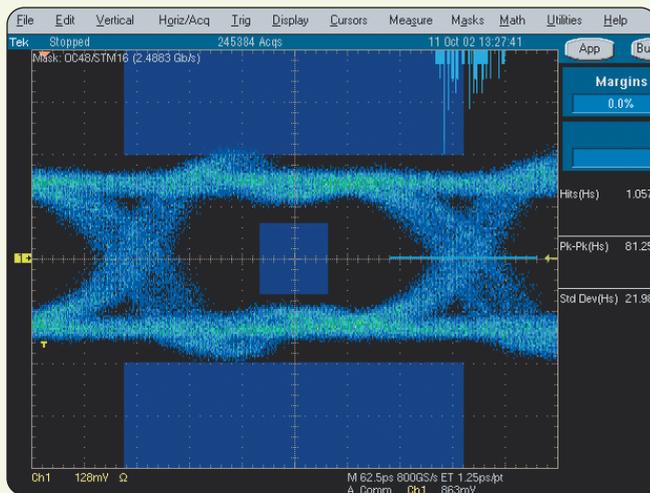


▶ *Two masks - with one thousand hits (left) and one million hits (right) - showing the increase in peak-to-peak jitter over time. These also demonstrate DPX™ technology acquiring more than 200K waveforms per second, with several measurements enabled.*

## Ensure the Integrity of Your Tests with Exceptional Instrument and Probing Performance

Tektronix oscilloscopes are the most advanced instruments for verification, debugging and characterization of sophisticated electronic designs. The TDS6000 and TDS7000 series provides you with high performance jitter analysis through exceptional trigger and acquisition performance. The TDS6604 Digital Storage Oscilloscope features the lowest jitter noise floor in the industry — 0.7ps rms — while the TDS7404 offers 4 GHz real-time bandwidth with a jitter noise floor of 1.5 ps rms.

Optimum performance starts at the connection to your device or system. The TDS6000 and 7000 series maintain signal fidelity and minimize loading with the TekConnect™ signal interconnect system and the most advanced active and differential probes in the industry. The TekConnect interface offers useful bandwidth up to 18 GHz at the oscilloscope input, while supporting the world's widest array of accessory signal acquisition solutions for high-performance, real-time oscilloscopes.

## Customize Your Setups to Efficiently Zero-In on Solutions

The TDSJIT3 jitter analysis software gives you a wide selection of setup options to best suit your measurement needs. These options allow you to:

► Measure multiple clock and data signals and the relationships between them on multiple inputs simultaneously.

► Select measurements from live signals, math and reference waveforms.

► Select the same measurement on multiple channels.

► Ensure reliable results with vertical and horizontal autoset functions.

► Display multiple measurements and plots, clearly showing trends such as frequency drift or a clock's response to power supply changes.

► Measure the setup-time for a specific data edge to the exact corresponding clock edge for all valid transitions in an entire acquisition.

► Specify criteria for sources, populations or gated regions in order to zero-in on problems.

► Take measurement snapshots, or log results of measurements, statistics or capture worst case waveforms for further analysis using TDSJIT3 or other OpenChoice™ tools.
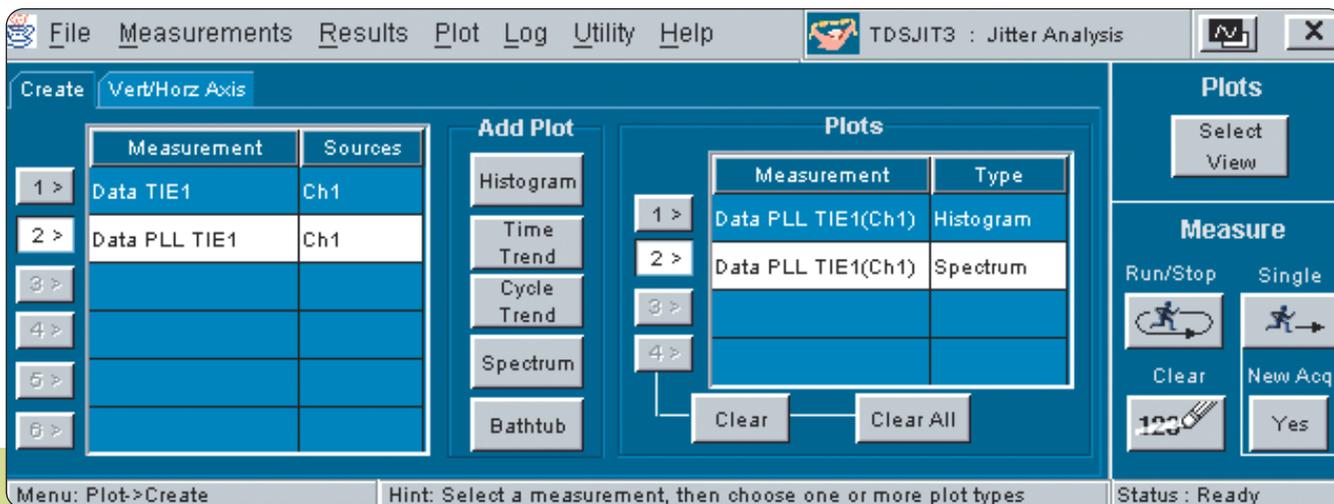


► *Figure 1.* Setup Options Menu

# Measure Basic Statistics and Histograms of Timing Parameters with Confidence.

TDSJIT3 software provides a comprehensive set of measurements for all basic jitter parameters. Since all known signals contain jitter that has a random component, statistical measures are used to properly characterize the jitter. The definitions of basic jitter properties are well understood, but the measurements can be complex. You can be confident that TDSJIT3 software provides the most comprehensive set of measurements for all basic jitter parameters and executes them precisely and accurately. Some of the common measures are:

▶ **Mean:** The arithmetic mean, or average, value of a measurement data set.

▶ **Standard Deviation:** The average amount by which a measurement varies from its mean value.

▶ **Maximum, Minimum and Peak-Peak:** Maximum and Minimum refer to values actually observed during a measurement interval; Peak-Peak is the difference between the Maximum minus the Minimum.

▶ **Population:** The number of individual observations included in a statistical data set.

▶ **Jitter Histogram:** A plot of measurement values in a data set versus the frequency of occurrence of the measurements.

▶ **Jitter vs. Time (Time Trend):** A plot of jitter value versus time (time trend can reveal repeating patterns that might indicate a modulation or other periodic component).

▶ **Jitter vs. Frequency (Jitter Spectrum):** A plot of the Fourier transform of the measurement data set (viewing jitter vs. time in the frequency domain can reveal periodic components that otherwise might be hidden in wideband noise).

## Examples of Basic Jitter Test Results
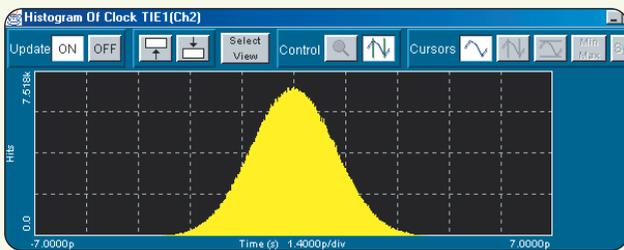
▶ *Jitter histogram for a Time-Interval Error (TIE) measurement. The continuous variable is mapped into 500 bins. The mean value is 0 nsec and the distribution is approximately Gaussian with a standard deviation under 1ps.*
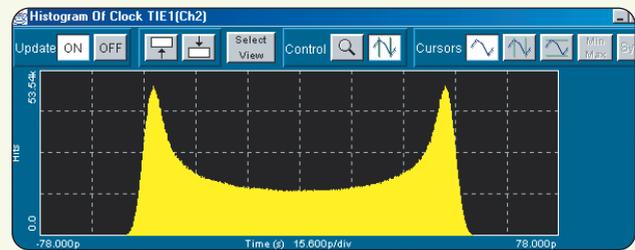
▶ *Jitter histogram of the result of the TIE of the above signal modulated by a sine wave, with a peak-to-peak value of about 100ps.*
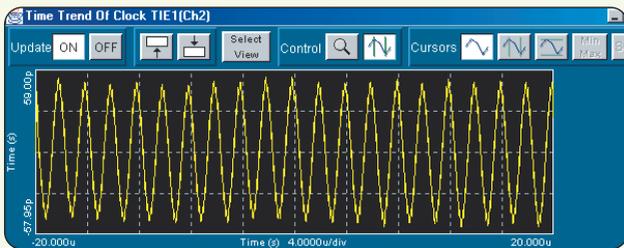
▶ *Jitter Time Trend. The pattern of jitter variation becomes apparent, and its correlation with one of several possible sources of coupled noise can be derived. The random component can still be seen as noise added to the sinusoidal modulation.*
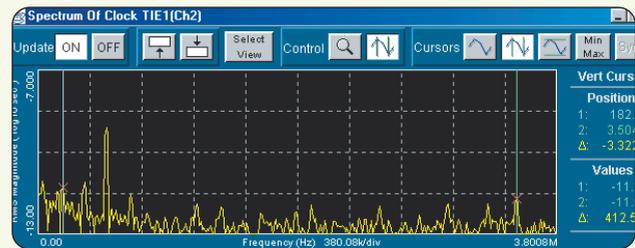
▶ *Jitter spectrum of the time trend plot. Harmonics of the triangle source are clearly defined.*
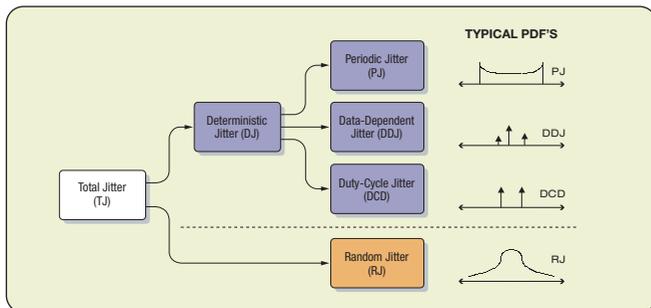
## Use Advanced Analysis to Open Your Eyes

TDSJIT3 software takes you far beyond the basic jitter measurements with unique advanced analysis tools to detect, quantify and identify jitter components. By decomposing jitter into its component parts, TDSJIT3 gives you unprecedented insight to track down and eliminate jitter sources — optimizing your designs for peak performance.

## Get to the Sources of Problems Using Jitter Decomposition

TDSJIT3's advanced tool set lets you decompose jitter and isolate random noise components from deterministic periodic, clock and data-dependent anomalies. Unique algorithms quantify the separate components and allow you to perform additional analysis to help correlate them with suspected sources. By focusing on those sources that can be controlled, you can optimize your designs for peak performance.

TDSJIT3 software decomposes jitter signals and measures values for each of the four components.

▶ **Random Jitter (RJ)** is timing noise that has no discernable pattern and is not readily predictable. The primary source of random noise in electrical circuits is thermal noise (Johnson noise or shot noise). RJ is assumed to have a Gaussian distribution and there is no bounded peak-to-peak value for the underlying distribution — the more samples one takes, the larger the measured peak-to-peak value will be.

▶ **Deterministic Jitter (DJ)** is timing jitter that is repeatable and predictable. The peak-to-peak value of DJ is bounded, and the bounds can be observed or predicted with high confidence based on a relatively low number of observations.

▶ **Periodic Jitter (PJ)** repeats in a cyclic fashion. Since a periodic waveform can be decomposed into a Fourier series of harmonically related sinusoids, this kind of jitter is sometimes called sinusoidal jitter. PJ is typically caused by external deterministic noise sources such as switching power-supply noise or a strong local RF carrier. It may also be caused by an unstable clock-recovery PLL.

▶ **Data-Dependent Jitter (DDJ)** is any jitter that is correlated with the bit sequences in a data stream. DDJ is often caused by the frequency response of a cable or device. Another common name for DDJ is Pattern Dependent Jitter (PDJ), and is the measured result of Inter-Symbol Interference, or ISI.

▶ **Duty-Cycle Distortion (DCD)** is the variation in duty cycle from the nominal value of 50%. There are two common causes of DCD: the slew rate for the rising edges differs from that of the falling edges or the decision threshold for a waveform is higher or lower than it should be because the signal DC average has shifted.



▶ *Figure 2. The jitter model first separates the total jitter (TJ) into random jitter (RJ) and deterministic jitter (DJ). The deterministic jitter is further subdivided into periodic jitter (PJ), duty-cycle dependent jitter (DCD), and data-dependent jitter (DDJ).*
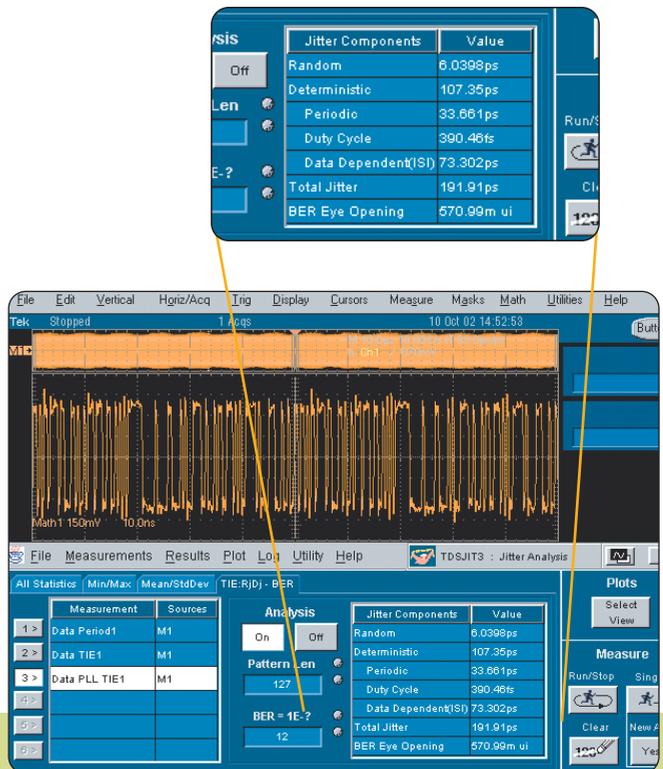


▶ *Figure 3. 2.5 Gb PLL TIE Rj/Dj with detail.*

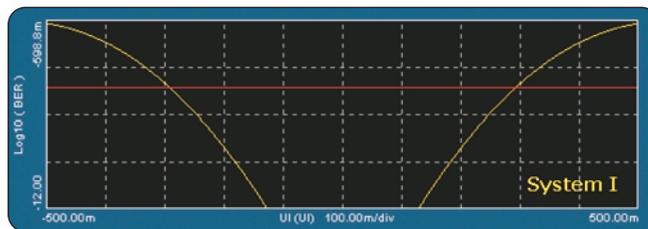## Predict Performance Using BER Characteristics

Using only peak-to-peak jitter or rms jitter measurements to characterize a design can lead to faulty conclusions. TDSJIT3 software separates the random and deterministic components and processes them into estimates of bit error rates (BER) to more accurately predict the behavior of designs in a range of conditions.

In this example, the jitter performance of two systems is compared. Both plots represent data sets of 42,000 observed edges — the red cursor on each plot corresponds to a BER of one part in 42,000, or $10^{-4.63}$. At this level, both of the systems show an eye opening of about 58%, and simply comparing the rms and peak-to-peak values makes it appear that the system in Figure 4 is the better of the two.

However, by separating the random and deterministic components and estimating bit error ratios, we find that the system in Figure 5 is better behaved. At a BER of $1e^{-12}$ (which is a frequent specification point for serial communication links) the eye for Figure 4 is only open 26%, while the eye for Figure 5 is open 37% — a significant difference, and could easily determine whether a system meets its requirements in actual use.



▶ *Figure 4.*



▶ *Figure 5.*

## Catch Those Elusive Intermittent Sources with Worst Case Analysis Tools

Some jitter sources occur at random or widely separated intervals. TSJIT3 lets you set up for extremely long measurement periods, lasting for hours or even days in order to catch the offenders. You can save only the Worst Case acquisitions from the entire measurement period and quickly pick out the offenders. The same tools can also be used to verify the stability of a design over long periods.

## Power Measurement and Analysis Software – TDSPWR2

TDSPWR2 power measurement software transforms a digital oscilloscope into a sophisticated analysis tool that quickly measures and analyzes power dissipation in power supply switching devices and magnetic components, and then generates detailed test reports in customizable formats. Use TDSPWR2 with a Tektronix TDS5000 Series or TDS7054/TDS7104 digital phosphor oscilloscope and differential and current probes, for a complete measurement system for power supply design and test.
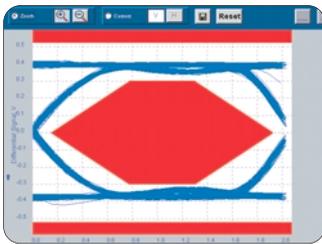
## USB2.0 Compliance Test Package – TDSUSB2

Tektronix offers the USB-IF approved TDSUSB2 and the TDS7000 DPO as the industry's first complete solution for USB 2.0 physical layer testing. TDSUSB2 provides pre-defined oscilloscope set-ups for a variety of tests, eliminating the need for manual set-ups. A comprehensive compliance test fixture enables probing for a wide range of tests.
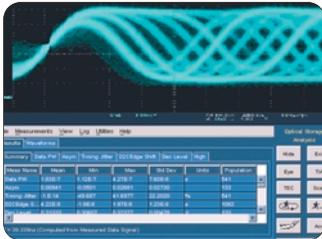
## Optical Storage Analysis and Measurement Software – TDSDVD

The TDSDVD optical storage analysis and measurement software package, coupled with Tektronix TDS5000 and TDS/CSA7000 Series digital phosphor oscilloscopes, is the first test tool to deliver the flexibility, analysis, time interval display, automatic industry-specific measurements, and familiar, analog-like display for design and test engineers developing state-of-the-art optical storage systems.

ISO 9001

## For more information:

Our web site offers valuable information that is available at the click of a mouse. Please visit **www.tektronix.com** to learn more about these products.

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