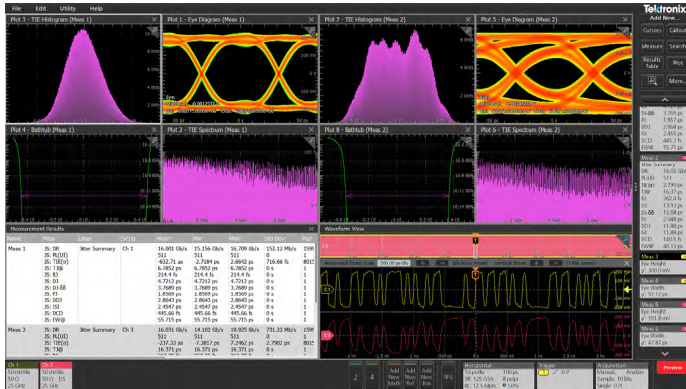


Advanced Jitter and Noise Analysis

5, 6, and 7 Series Oscilloscope Application Datasheet



Built on decades of Tektronix expertise and the industry-standard DPOJET analysis package, Advanced Jitter Analysis (Opt. DJA) delivers industry-leading accuracy, analysis depth, and visualization for characterizing and debugging today's high-speed serial designs. Integrated directly into the oscilloscope's automatic measurement system, DJA combines advanced jitter decomposition, flexible clock recovery, and powerful multi-measurement analysis to accelerate root-cause identification and provide greater confidence in measurement results. Advanced Jitter plus Noise Analysis (Opt. DJAN) extends DJA by separating noise into random and deterministic components, accounting for interactions between jitter and noise, and predicting eye closure at target bit error rates (BER) for more accurate root-cause analysis.

Key standard measurement features

- Basic timing measurements including period, frequency, rise/fall times, pulse width, and duty cycle
- Time Interval Error (TIE) measurement
- Phase Noise measurement and plot
- Graphical analysis with Histograms, Time Trends, Transfer Functions, and Spectrums
- Programmable clock recovery including software PLL
- Selectable high-limit and low-limit measurement bounds

Key optional Jitter Analysis (Opt. DJA) features

- Jitter and Timing analysis for analog and digital clock and data signals
- Real-time Eye Diagram (RT-Eye®) analysis for rapid insight
- Automatic bit rate and pattern length detection simplifies setup
- Selectable high-pass and low-pass measurement filters
- Jitter plots including Time Trend, Eye Diagram, Histogram, Composite Histogram, Spectrum, Bathtub Curve, and SSC Profile

- Spectral separation method measures and derives components directly from the signal for a fast, accurate path to root cause (U.S. Patent No. 8,594,169)
- Distinguishes bounded uncorrelated jitter (BUJ) from random jitter (RJ) to identify crosstalk-related impairments and improve total jitter accuracy
- Industry-standard dual-Dirac statistical modeling complements spectral separation with compliance-driven evaluation
- Automated eye diagram mask testing for clear pass/fail results and margin analysis

Key Advanced Jitter plus Noise Analysis (Opt. DJAN) features*

*Advanced Jitter plus Noise Analysis (Opt. DJAN) extends and requires Advanced Jitter Analysis (Opt. DJA).

- Separates random and deterministic noise components to support root-cause analysis beyond traditional jitter analysis
- Accounts for and quantifies how jitter manifests as noise and noise as jitter for more accurate root-cause analysis (U.S. Patent No. 9,294,237)
- Predicts and visualizes eye closure and available margin at target BERs using BER Eye and BER Contour plots
- Visualizes noise distributions and signal behavior using Correlated Eye, PDF Eye, Noise Bathtub, and Composite Noise Histogram plots

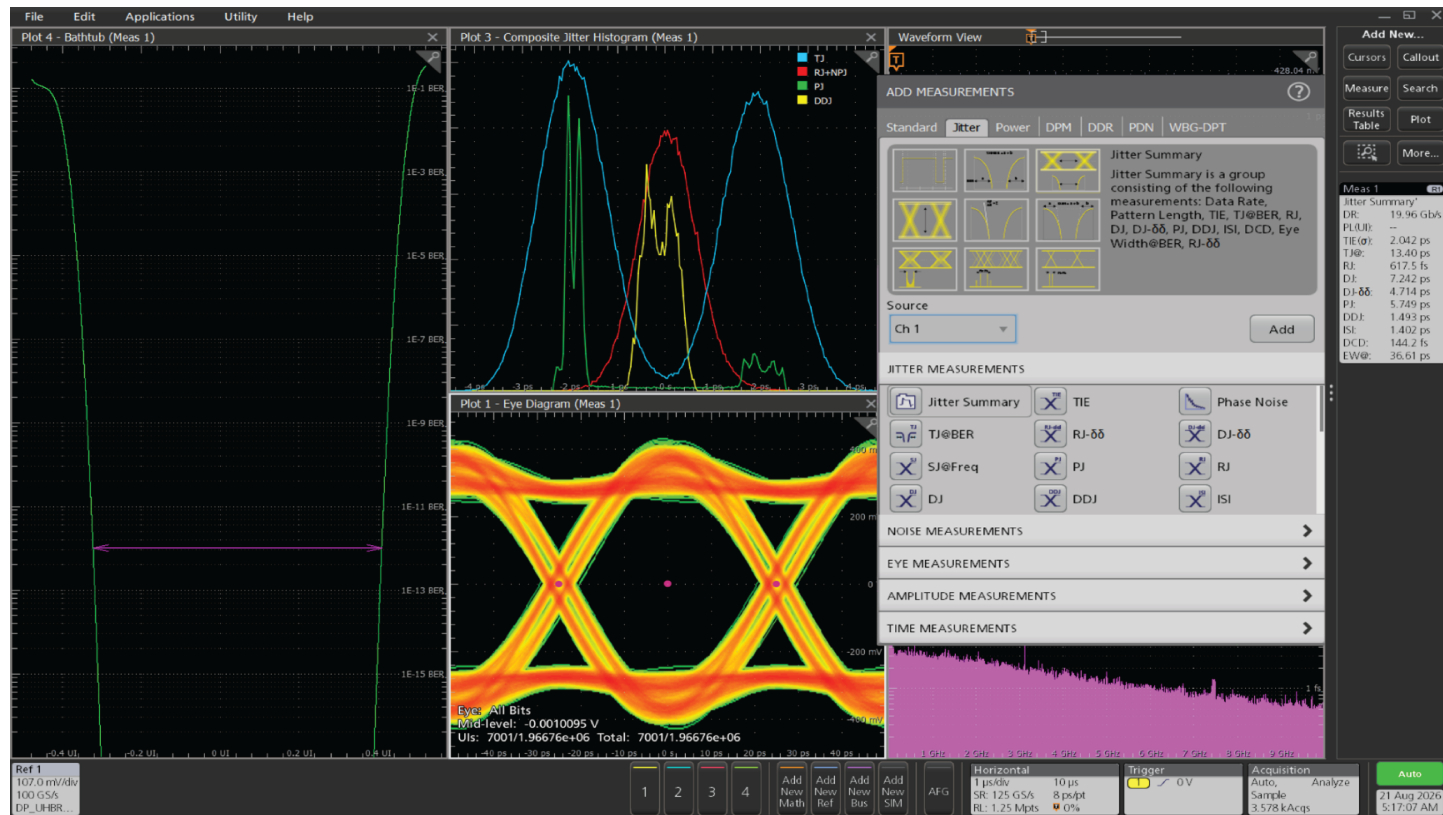
Applications

- Quantify signal amplitude and timing parameters and margins
- Debug complex embedded systems
- Characterize performance of high-speed serial and parallel bus designs
- Characterize clock and data jitter/noise and signal integrity
- Characterize PLL dynamic performance
- Characterize modulation of spread spectrum clock circuits
- Characterize jitter generation, transfer, and tolerance

Jitter, Noise, and Eye Diagram measurements

The Advanced Jitter and Noise Analysis tools extend the capability of Tektronix real-time oscilloscopes, performing complex measurements and analysis of clock, serial, and parallel data signals captured in continuous or single-shot acquisition modes. Measurements can be made on any of the analog FlexChannel® inputs, any active math waveforms, or any active reference waveforms.

Advanced Jitter and Noise Analysis is integrated into the oscilloscope's automatic measurement system, allowing essentially unlimited combinations of measurements to be enabled and displayed.



Jitter measurements configuration menu.

The JITTER MEASUREMENTS panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

Jitter measurement	Description
Jitter Summary	Jitter Summary consists of a group of measurements: Data Rate, Pattern Length, TIE, TJ@BER, RJ, RJ-δδ, DJ, DJ-δδ, PJ, DDJ, ISI, DCD, Eye Width@BER, and Eye Height@BER.
TIE	Time Interval Error is the time difference between an edge in the source waveform and the corresponding edge in a recovered reference clock.
Phase Noise	Phase Noise is the RMS magnitude of all integrated jitter falling within a user-specified offset range of the fundamental clock frequency.
TJ@BER	Total Jitter at a specified Bit Error Rate is the predicted peak-to-peak amplitude of the jitter that will only be exceeded with a probability equal to the bit error rate.

Jitter measurement	Description
RJ-δδ	Dual-Dirac Random Jitter is the random jitter component determined using the dual-Dirac statistical model.
DJ-δδ	Dual-Dirac Deterministic Jitter is the deterministic jitter component determined using the dual-Dirac statistical model.
PJ	Periodic Jitter is the peak-to-peak amplitude of the uncorrelated sinusoidal components of the deterministic jitter.
PJ(h)*	Periodic Jitter (horizontal) is the portion of PJ attributable to periodic timing variations in the waveform.
PJ(v)*	Periodic Jitter (vertical) is the portion of PJ attributable to periodic amplitude variations appearing as timing variations.
RJ	Random Jitter is the RMS magnitude of all random timing errors following a Gaussian distribution.

Jitter measurement	Description
RJ(h)*	Random Jitter (horizontal) is the portion of RJ attributable to random timing variations in the waveform.
RJ(v)*	Random Jitter (vertical) is the portion of RJ attributable to random amplitude variations appearing as timing variations.
DJ	Deterministic Jitter is the peak-to-peak amplitude of all timing errors that exhibit deterministic behavior.
DDJ	Data Dependent Jitter is the peak-to-peak amplitude of the component of the deterministic jitter correlated with the data pattern in the waveform.
ISI	Intersymbol Interference is the difference between the maximum and minimum Data-Dependent Jitter (DDJ) per edge, measured across all rising edges or all falling edges, whichever range is greater.
DCD	Duty Cycle Distortion is the peak-to-peak amplitude of the component of the deterministic jitter correlated with the signal polarity.
SRJ	Sub-Rate Jitter is the composite jitter due to periodic components at 1/2, 1/4, and 1/8 of the data rate.
J2	J2 is the total jitter at a bit error rate of 2.5e-3.
J9	J9 is the total jitter at a bit error rate of 2.5e-10.
NPJ	Non-Periodic Jitter is the portion of the Bounded Uncorrelated Jitter (BUJ) that is random. BUJ excludes DDJ, DCD, and RJ.
F/2	F/2 is the peak-to-peak amplitude of the periodic jitter occurring at 1/2 of the data rate.
F/4	F/4 is the peak-to-peak amplitude of the periodic jitter occurring at 1/4 of the data rate.
F/8	F/8 is the peak-to-peak amplitude of the periodic jitter occurring at 1/8 of the data rate.

* Available with Advanced Jitter plus Noise Analysis (Opt. DJAN).

The NOISE MEASUREMENTS* panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

Noise measurement	Description
Noise Summary	Noise Summary consists of a group of measurements: TN@BER, RN, DN, PN, DDN, DDN(0), DDN(1), Height@BER, and Unit Amplitude.
TN@BER	Total Noise at a specified bit error rate (BER) predicts the peak-to-peak vertical eye closure exceeded with a probability equal to the BER.

Noise measurement	Description
RN	Random Noise is the RMS magnitude of non-deterministic Gaussian-distributed vertical deviations from the nominal bit amplitude.
RN(h)	Random Noise (horizontal) is the portion of RN attributable to random jitter appearing as equivalent vertical displacement.
RN(v)	Random Noise (vertical) is the portion of RN attributable to random vertical displacement of the waveform.
DN	Deterministic Noise is the peak-to-peak amplitude of vertical deviations from nominal bit amplitude that exhibit deterministic behavior.
PN	Periodic Noise is the peak-to-peak amplitude of periodic deterministic noise uncorrelated with the data pattern.
PN(h)	Periodic Noise (horizontal) is the portion of PN attributable to periodic jitter appearing as equivalent vertical displacement.
PN(v)	Periodic Noise (vertical) is the portion of PN attributable to periodic vertical displacement of the waveform.
DDN	Data-Dependent Noise is the total vertical eye closure due to bit pattern-correlated vertical variations.
DDN(0)	Data-Dependent Noise for 0 bits is the peak-to-peak amplitude of pattern-correlated vertical variations of low bits from the nominal low level.
DDN(1)	Data-Dependent Noise for 1 bits is the peak-to-peak amplitude of pattern-correlated vertical variations of high bits from the nominal high level.
NPN	Non-Periodic Noise is the dual-Dirac magnitude of the random portion of Bounded Uncorrelated Noise (BUN).
Unit Amplitude	Unit Amplitude is the nominal eye amplitude at the eye center, defined by the mean DDN(1) high and DDN(0) low levels.
Height@BER	Eye Height at a specified BER is the predicted vertical eye opening at the target bit error rate.

The EYE MEASUREMENTS panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

Eye measurement	Description
Eye Height	Eye Height is the minimum vertical eye opening at the center of the recovered unit interval.
Eye Width	Eye Width is the minimum horizontal eye opening at the user-specified reference level.
Eye High	Eye High is the amplitude of a high ("1") bit measured at a user-specified location within the recovered unit interval.
Eye Height@BER	Eye Height@BER is the predicted vertical eye opening that will be violated with a probability equal to the bit error rate.
Eye Width@BER	Eye Width@BER is the predicted horizontal eye opening that will be violated with a probability equal to the bit error rate.
Eye Low	Eye Low is the amplitude of a low ("0") bit measured at a user-specified location within the recovered unit interval.
Q-Factor	Q-Factor is the ratio of the vertical eye opening to the RMS vertical noise measured at a user-specified location within the recovered unit interval.
Eye Mask Autofit	Automatically adjusts the position of the Eye Mask to minimize the number of mask hits.

The AMPLITUDE MEASUREMENTS panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

Amplitude measurement	Description
Bit High	Bit High is the amplitude of a "1" bit. The amplitude is measured over a user-specified portion at the center of the recovered unit interval.
Bit Low	Bit Low is the amplitude of a "0" bit. The amplitude is measured over a user-specified portion at the center of the recovered unit interval.
Bit Amplitude	Bit Amplitude is the difference between the amplitudes of the "1" bit and the "0" bit surrounding a transition. The amplitude is measured over a user-specified portion at the center of the recovered unit interval.
DC Common Mode	DC Common Mode is the arithmetic mean of the common mode voltage of two sources.
AC Common Mode (Pk-Pk)	AC Common Mode (Pk-Pk) is the peak-to-peak difference between the two sources' common mode voltages.

Amplitude measurement	Description
Differential Crossover	Differential Crossover is the voltage level of a differential signal pair at the crossover point(s).
T/nT Ratio	T/nT Ratio is the ratio of non-transition bit voltage (second and subsequent bit voltage after a transition) to its nearest preceding transition bit voltage (first bit voltage after the transition). Bit voltages are measured at the interpolated midpoint of the recovered unit interval.

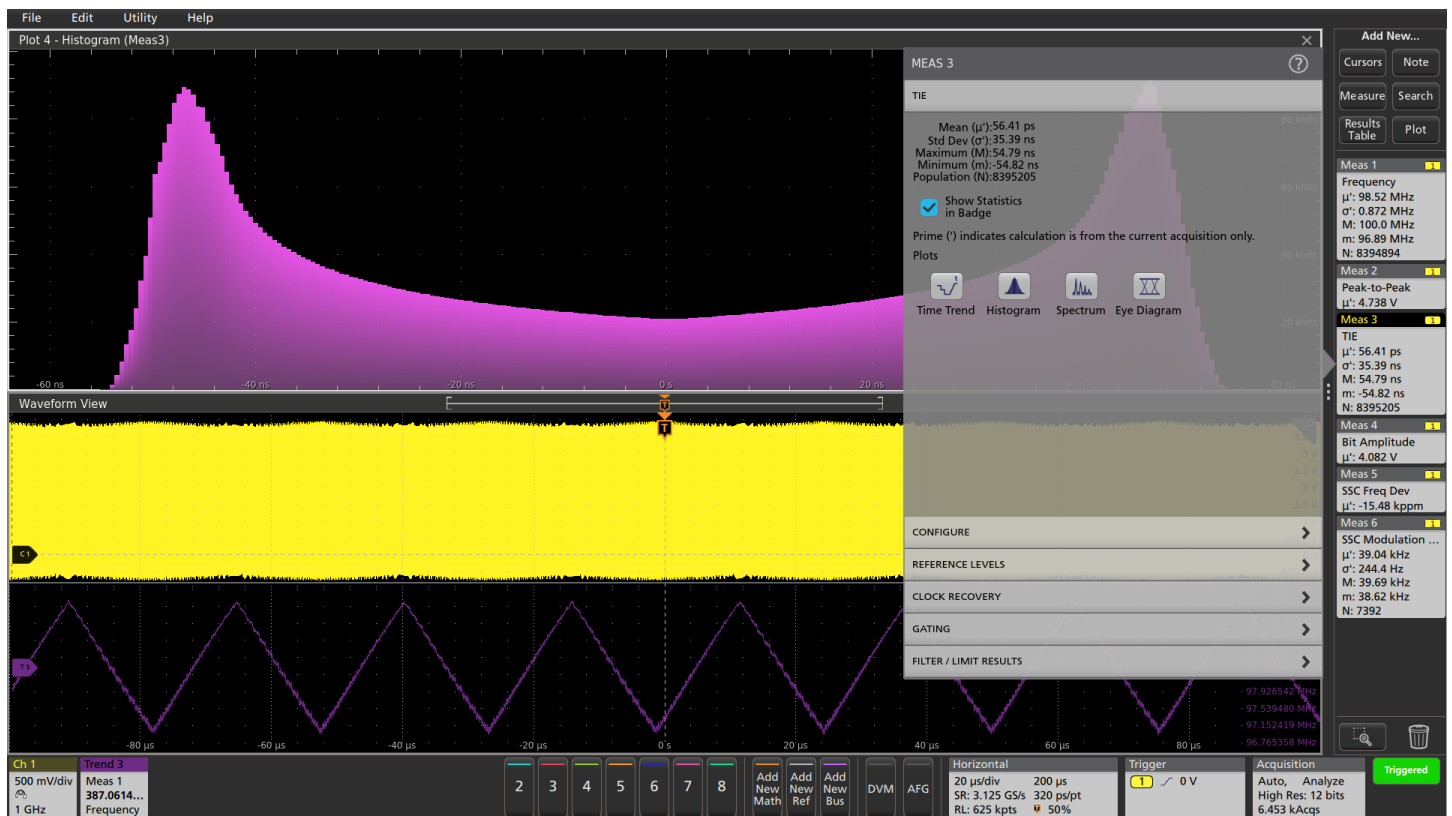
The TIMING MEASUREMENTS panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

Timing measurement	Description
SSC Freq Dev	SSC Frequency Deviation is the Spread Spectrum Clock frequency deviation. This measurement enables a time trend plot of the spread spectrum clock modulation profile.
SSC Modulation Rate	SSC Modulation rate is the modulating frequency of a Spread Spectrum Clock.
SSC Slew Rate	SSC Slew Rate is the rate of change of the clock frequency due to spread spectrum modulation.
Pattern Length	Pattern Length measures the number of symbols in the smallest repeating sequence.
Data Rate	Data Rate is the reciprocal of the Unit Interval (UI), measured for each bit in the acquired record.

Multi-measurement configuration

As a measurement is enabled, the mean value of the measurement appears in a badge at the right side of the display. Double-tapping the badge opens the configuration menu for that measurement, enabling the user to display a summary of the measurement statistics in the badge, display the measurement values in one or more relevant plot formats, and configure the automatic measurement parameters (including signal type, reference levels, clock recovery method, gating, filtering, and limits). These measurement parameters can be applied globally to all measurements, or just to individual measurements.

As an example, jitter measurements on a spread spectrum clock are based on a reference phased locked loop (PLL) for clock recovery. Typically, the PLL is defined to filter out high-frequencies and track the effects of intentional low-frequency jitter. The result is a more open eye diagram. However, in cases where it is desired to see the effects of clock jitter on the device under test, constant clock recovery can be used. These measurements can be made at the same time using the flexible measurement configuration features.



Configuration menu for one of many selected measurements on a spread spectrum clock signal.

Data visualization

Numerical jitter and eye-diagram analysis measurement results are critical to verifying that the design meets or exceeds its specifications. However, deep understanding and successful system debug requires insight beyond a simple parametric measurement result. What are the statistical variations in the measurement? How does the parameter vary over time? How do these variations correlate with other activity within the design?

For example, analysis of a spread spectrum clock signal may show the average clock frequency and maximum frequency deviation. The frequency variation should be a controlled, low-frequency jitter. Is the frequency actually varying as designed? The Advanced Jitter Analysis application can plot the frequency and Time Interval Error (TIE) measurement time trends along with the clock waveform, and plot the histograms and spectrums of the measurements, providing insight into the circuit behavior in multiple domains.



Analysis of a spread spectrum clock signal, showing the 39 kHz triangular modulation on the 98 MHz clock.

By default, the spectral plot shows the entire jitter content of the signal. To examine the low-frequency jitter components, the spectrum can be zoomed and measured with cursors. While zoomed, the overview window always provides context of the zoomed area in relation to the entire plot.

Advanced Jitter and Noise Analysis provides customizable displays, showing measurement values and statistics in measurement badges or results tables, as well as eye diagrams, trend plots, histograms, bathtub plots, and spectral plots.

Composite Jitter Histograms overlay Total, Periodic, Random-plus-BUJ, and Data-Dependent jitter in a single plot, enabling direct comparison and faster root-cause identification.

Trend analysis quickly shows engineers how timing parameters change over time, like frequency drift, PLL startup transients, or a circuit's response to power supply changes.

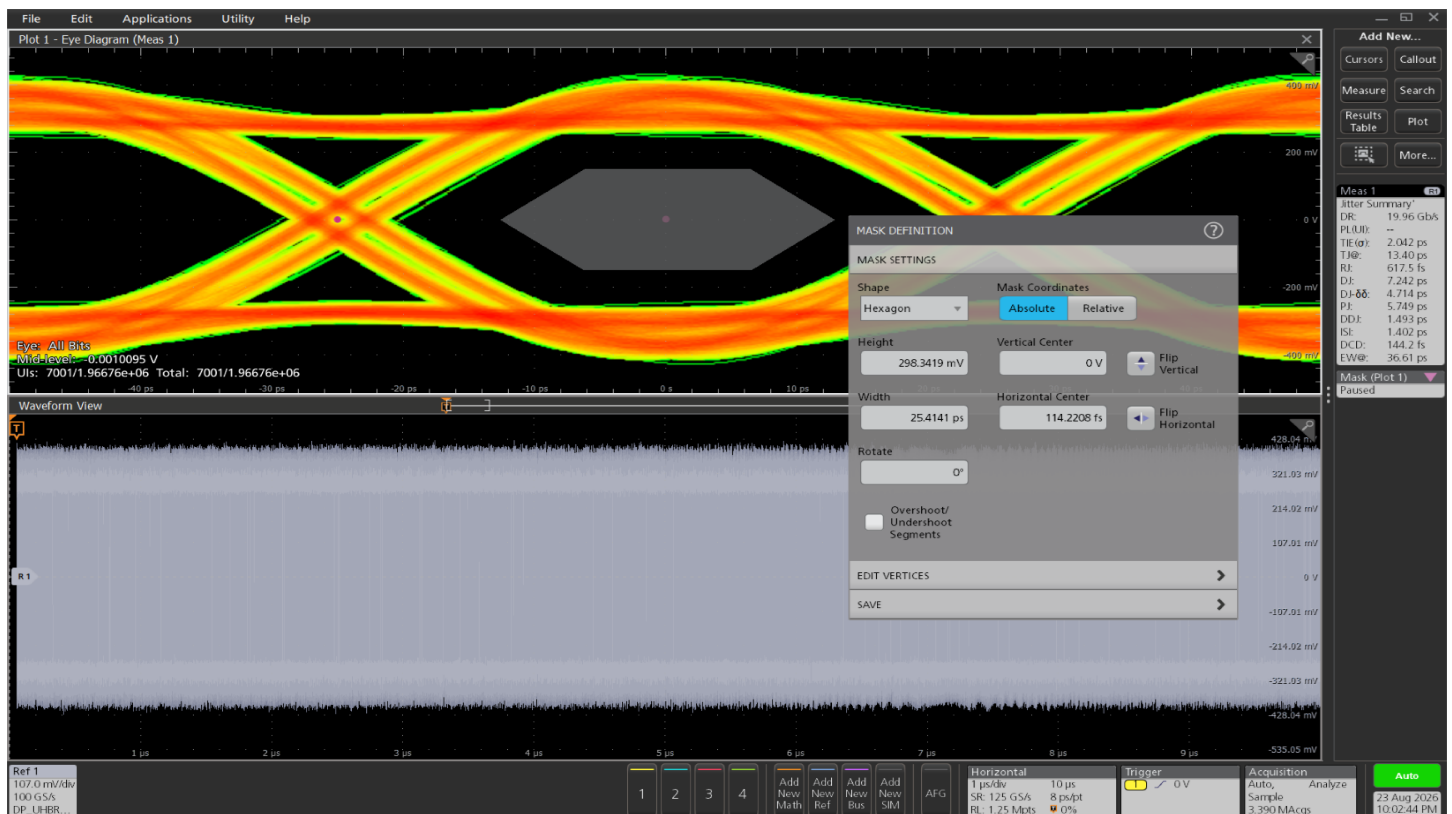
Spectrum analysis quickly shows the precise frequency and amplitude of jitter and modulation sources for easy, rapid identification.

Finding sources like adjacent oscillators and clocks, power supply noise, or signal crosstalk is no longer a tedious chore. The plots are all interactive, allowing the user to zoom in on interesting details and make cursor measurements on the plot. And waveforms and plots can be annotated and saved, enabling collaboration with the design team and suppliers.

Eye diagram mask testing

Eye diagrams are powerful representations of serial signals. Coupled with the automated pass/fail eye diagram mask testing capability of the jitter analysis application, this graphical measurement technique allows you to use a single test to verify signal amplitudes and noise, timing jitter, rise-times, and fall-times.

As with so many features, the number of segments in the mask test is essentially unlimited. When you add segments to the mask, the mask results badge at the right side of the display expands to indicate the mask violations (hits) for each segment.

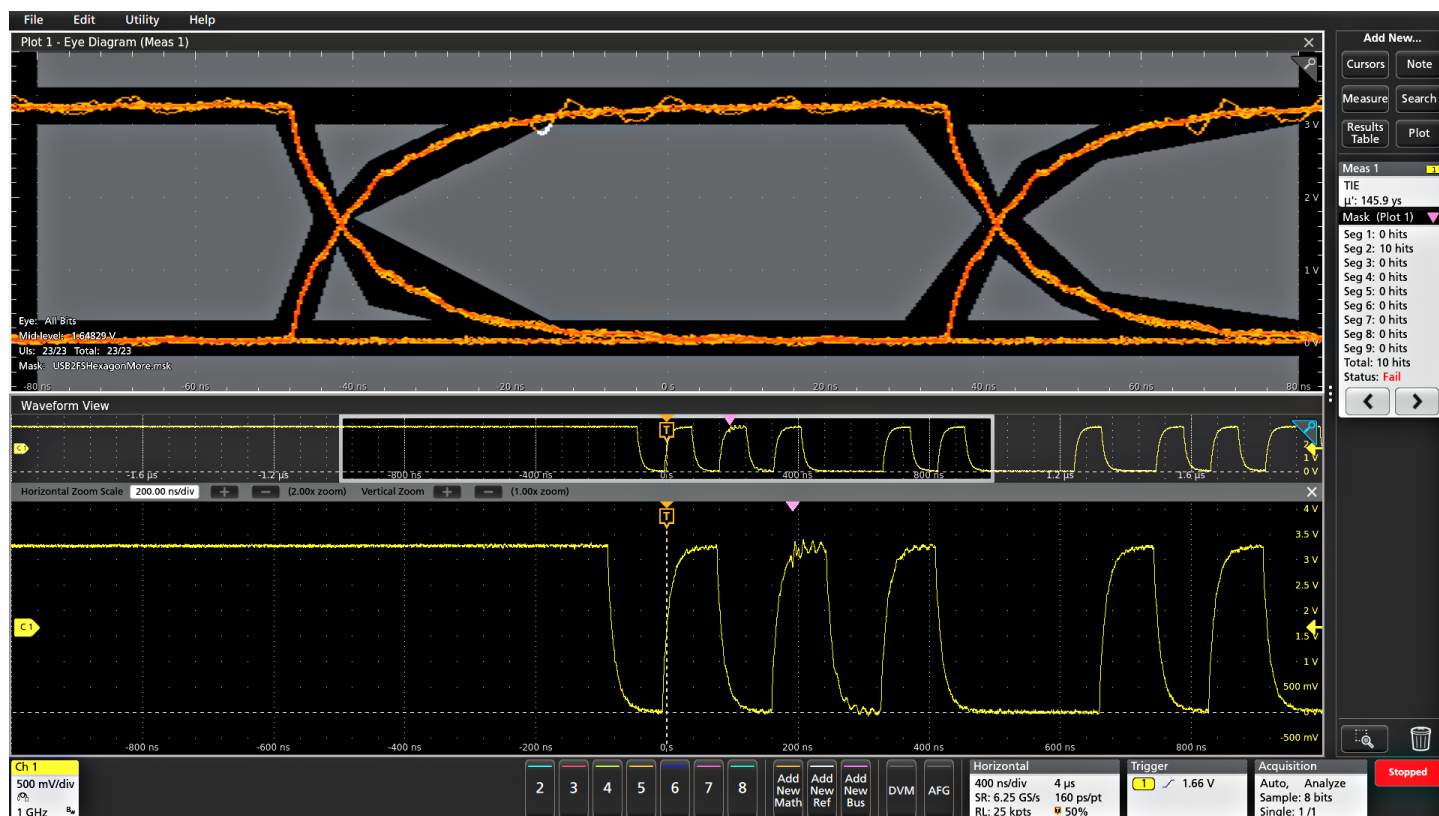


A simple eye diagram mask test setup.

Eye diagram masks are composed of graphical areas on the display which are defined by simple text or XML files. For example, the following three-line text file, with each line containing four X-Y time and voltage coordinates, defines the mask shown above:

- :MASK:USER:SEG1:POINTS -80E-9,3.5,80E-9,3.5,80E-9,4,-80E-9,4;
- :MASK:USER:SEG2:POINTS -35E-9,1.7,0.0,0.5,35E-9,1.7,0.0,3.0;
- :MASK:USER:SEG3:POINTS -80E-9,-0.7,80E-9,-0.7,80E-9,-0.2,-80E-9,-0.2;

Whether the mask test is run continuously, such as over the weekend, or for a specified number of acquisitions, all mask hits are accumulated. The hits are shown as white pixels in the gray mask areas, and are displayed in the results badge. At the end of the test, the total number of hits is compared to the user-selectable threshold and the test is clearly marked as Pass or Fail.



Easy navigation to eye diagram mask violations.

When mask hits occur in the eye diagram plot, the corresponding points in the time-domain waveform are marked with a purple triangle search mark. When acquisitions are stopped, you can use the navigation arrows in the results badge to search in the current acquisition for the locations that caused the mask violations. If mask hits are excessive on long duration acquisition, an Eye Mask Autofit function can be enabled to automatically adjust the position of the Eye Mask while retaining the size and shape of the mask relative to the waveform. This can dramatically speed up analysis of timing and amplitude errors that undermine serial signal performance.

Mask margin provides a quantitative measure of how closely a signal approaches the defined eye mask limits. By calculating the tolerance area around the mask, mask margin shows how much the eye opening can shrink, shift, or distort before a violation occurs. This analysis not only determines strict pass/fail compliance, but also reveals the degree of margin available, giving engineers deeper insight into signal robustness and design reliability.

For further analysis and documentation, after a mask test has completed, you can also export the plot display, the eye diagram data, and the mask hits results to your computer.

Ordering information

Options	Description
Opt. 5-DJA	Advanced Jitter Analysis application preinstalled on a new 5 Series B MSO instrument.
Opt. 5-DJAN	Advanced Jitter plus Noise Analysis application preinstalled on a new 5 Series B MSO instrument. Requires Opt. 5-DJA.
Opt. 6-DJA	Advanced Jitter Analysis application preinstalled on a new 6 Series B MSO instrument.
Opt. 6-DJAN	Advanced Jitter plus Noise Analysis application preinstalled on a new 6 Series B MSO instrument. Requires Opt. 6-DJA.
Opt. 7-DJA	Advanced Jitter Analysis application preinstalled on a new 7 Series DPO instruments.
Opt. 7-DJAN	Advanced Jitter plus Noise Analysis application preinstalled on a new 7 Series B MSO instrument. Requires Opt. 7-DJA.

Upgrade to existing instrument

5 Series B MSO Node-Locked license	5 Series B MSO Floating license	6 Series B MSO Node-Locked license	6 Series B MSO Floating license	Description
SUP5-DJA	SUP5-DJA-FL	SUP6-DJA	SUP6-DJA-FL	Advanced Jitter Analysis application license to upgrade an existing instrument
SUP5-DJAN	SUP5-DJAN-FL	SUP6-DJAN	SUP6-DJAN-FL	Advanced Jitter plus Noise Analysis application license to upgrade an existing instrument. Requires Opt. DJA.

7 Series DPO Node-Locked license	7 Series DPO Floating license
7-DJA	7-DJA-FL
7-DJAN	7-DJAN-FL

NOTE: Option software is part of the instrument firmware. Always download and install the latest version of the firmware. User documentation for options is part of the oscilloscope documentation.

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