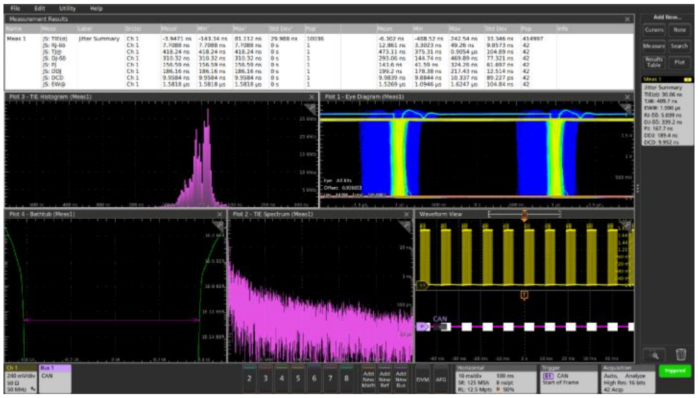
Tektronix®

5 Series MSO Advanced Jitter Analysis Application

5-DJA Datasheet



Based on the industry-standard Tektronix DPOJET eye-diagram, jitter, noise, and timing analysis package, the 5-DJA Advanced Jitter and Eye Diagram Analysis option provides the highest sensitivity and accuracy available in real-time instruments. Unlike competitive jitter analysis applications, option 5-DJA integrates the comprehensive jitter and eye-diagram analysis with the user interface of the 5 Series MSO's automatic measurement system. The 5-DJA measurements, measurement plots, and advanced jitter decomposition algorithms simplify discovering signal integrity concerns and jitter and their related sources in today's high-speed serial, digital, and communication system designs.

Key standard measurement features of the 5 Series MSO

- Basic timing parametric measurements such as period, frequency, rise/fall times, pulse width, and duty cycle
- Time Interval Error (TIE)
- Phase Noise
- Many graphical tools such as Histograms, Time Trends, and Spectrums
- Programmable software clock recovery including software PLL [1]
- Selectable high- and low-limit measurement bounds

Key features of Jitter Analysis (option 5-DJA)

- Jitter and Timing Analysis for analog and digital clock and data signals
- Real-time Eye-diagram (RT-Eye®) Analysis [2]
- Automatic bit rate and pattern length detection eases measurement configuration
- Selectable high- and low-pass measurement filters
- Multiple plot types to view and analyze jitter: Time Trend, Eye Diagram, Histogram, Spectrum, Bathtub Curve, and SSC Profile
- Accurate jitter analysis using the spectral and Q-scale methods for detailed decomposition of jitter components, including the extraction of industry-standard dual-Dirac model parameters
- Jitter separation algorithms accurately measure the effects of bounded uncorrelated jitter (BUJ) which enables precise TJ measurements

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

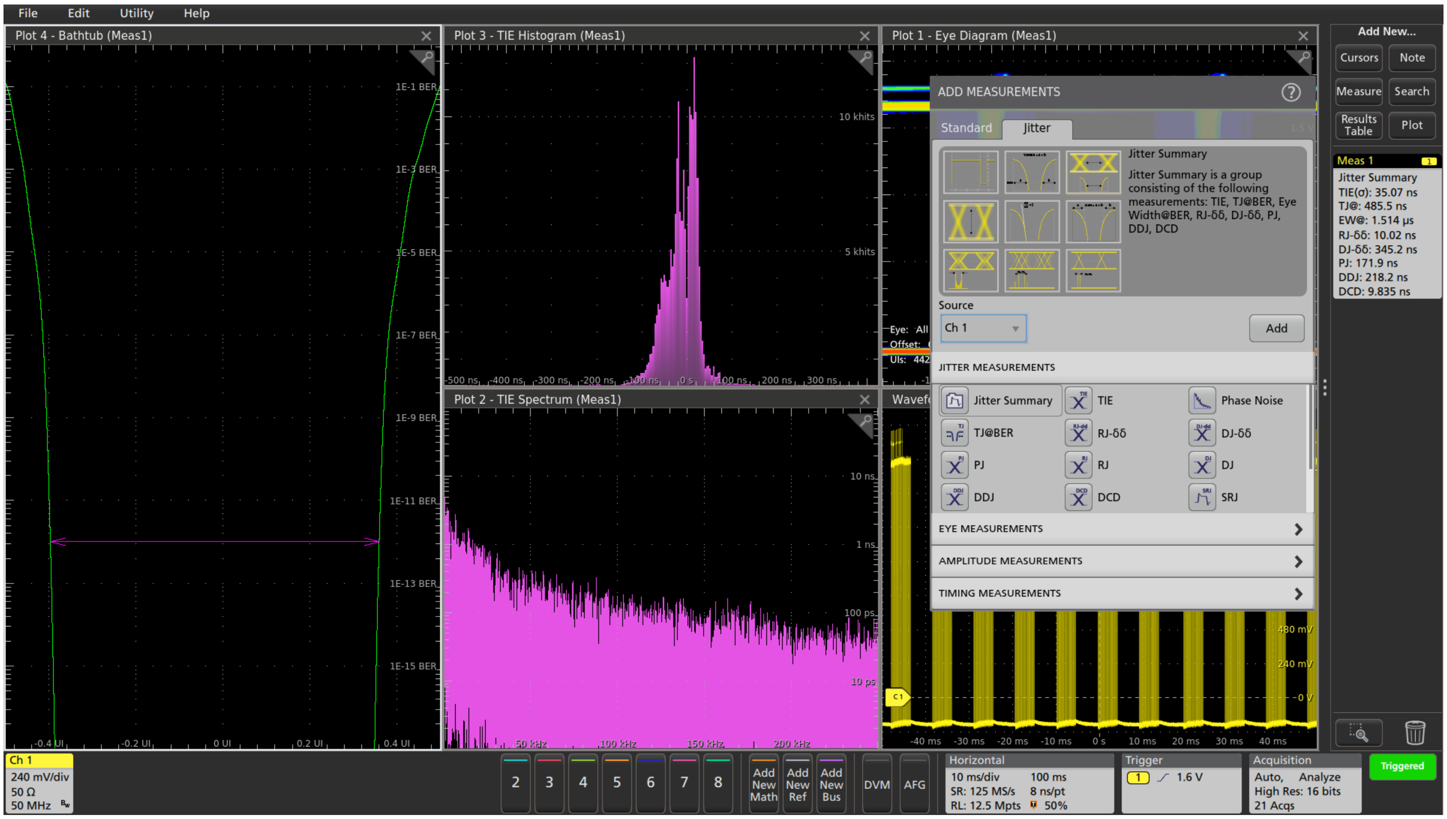
1 Patented USPTO #6,812,688

2 Patented USPTO #6,836,738

Jitter and eye-diagram measurements

The Advanced Jitter and Eye-diagram Analysis tools extend the capability of Tektronix 5 Series MSO real-time oscilloscopes, performing complex measurements and analysis of clock, serial, and parallel data signals captured in continuous or single-shot acquisition modes. The jitter and eye-diagram analysis measurements can be made on any of the analog FlexChannel® inputs, any active math waveforms, or any active reference waveforms.

Advanced Jitter and Eye-diagram Analysis is integrated into the 5 Series MSO automatic measurement system, allowing essentially unlimited combinations of standard and jitter measurements to be enabled and displayed. Within the Add New Measure configuration menu, the standard amplitude and timing measurements are on the Standard tab and the jitter measurements are on the Jitter tab.



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: TIE, TJ@BER, Eye Width@BER, RJ-δδ, DJ-δδ, PJ, DDJ, and DCD.
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.
RJ-δδ	Dual-Dirac Random Jitter is random jitter based on a simplifying assumption that the histogram of all deterministic jitter can be modeled as a pair of equal-magnitude Dirac functions.
DJ-δδ	Dual-Dirac Deterministic Jitter is deterministic jitter based on a simplifying assumption that the histogram of all deterministic jitter can be modeled as a pair of equal-magnitude Dirac functions.
PJ	Periodic Jitter is the peak-to-peak amplitude of the uncorrelated sinusoidal components of the deterministic jitter.
RJ	Random Jitter is the RMS magnitude of all random timing errors following a Gaussian distribution.
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.
DCD	Duty Cycle Distortion is the peak-to-peak amplitude of the component of the deterministic jitter correlated with the signal polarity.

Jitter measurement	Description
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.

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.

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.

Amplitude measurement	Description
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.
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.

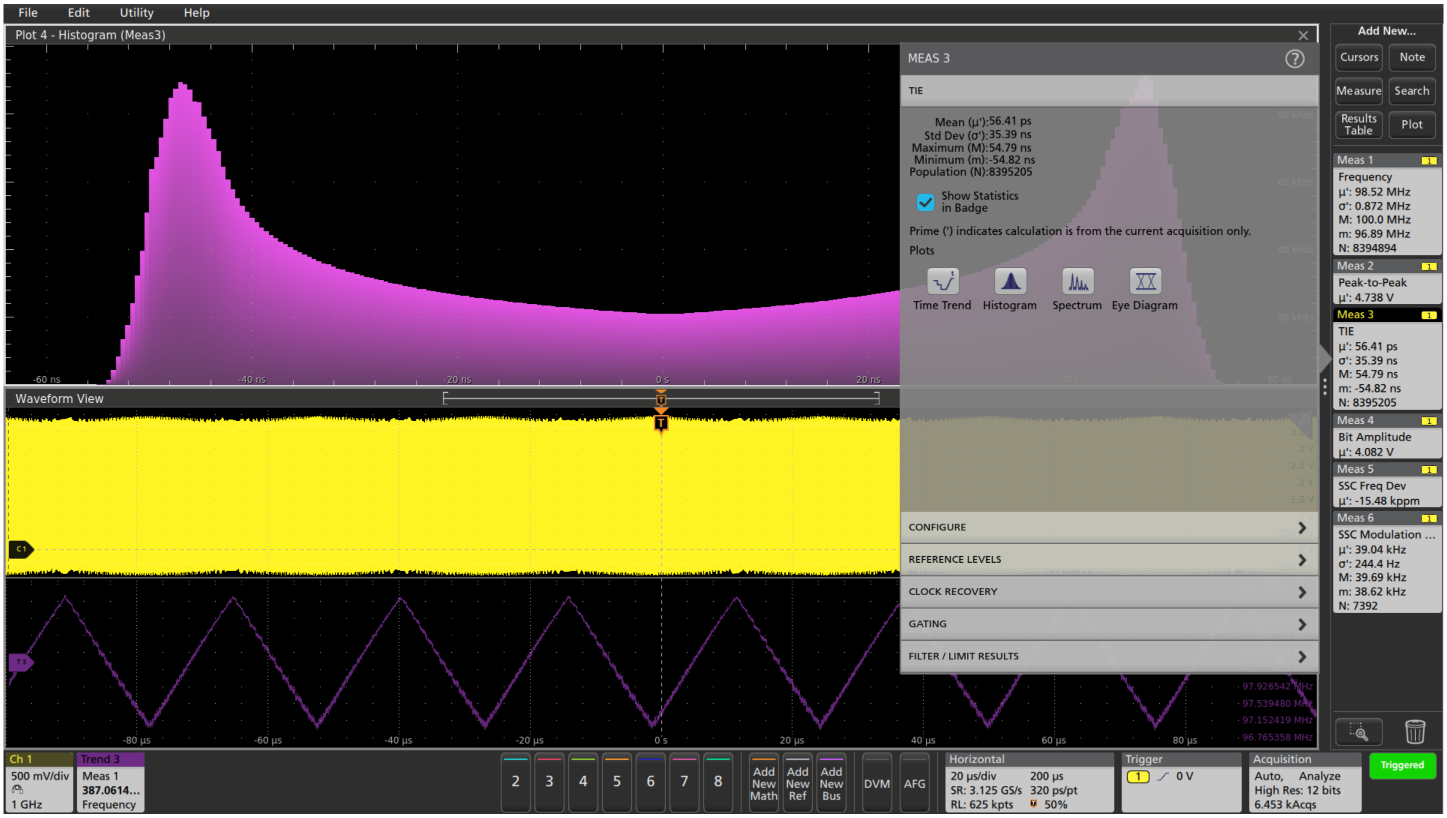
The TIMING MEASUREMENTS panel in the ADD MEASUREMENTS configuration menu on the Jitter tab contains:

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.

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 exceed 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 5 Series MSO with option 5-DJA can plot the frequency and Time Interval Error (TIE) measurement time trends along with the clock waveform, as well as plotting 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 Eye-diagram 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.

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.

Ordering information

New instrument option

Opt. 5-DJA	Order to preinstall option 5-DJA on a new instrument.

Upgrade to existing instrument

SUP5-DJA	Order to obtain a license file to enable option 5-DJA on an existing instrument. [3]

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

3 Option software is part the 5 Series MSO instrument firmware. User documentation for options is part of the oscilloscope documentation.

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