# *Characterize Jitter Using Histograms*

## Direct Readout Of Jitter Using Histograms Of Parameters

Jitter measurements are among the most common applications for LeCroy's 9300 series oscilloscopes. With an extensive range of automatic measurement parameters it is easy to measure the key timing parameters such as width , period, and duty cycle. LeCroy offers statistical analysis of these parameters, over multiple acquisitions, providing direct readout of the mean, lowest and highest value, and standard deviation (sigma) of up to 5 measurement parameters as shown in figure 1.

The standard deviation (sigma) provides direct readout of the rms jitter for that parameter. The difference between the lowest and highest value is the peak to peak jitter. For example, in figure 1 the width has an rms jitter of 38 ns and a peak to peak jitter of 130 ns.

Many other digital oscilloscopes offer little beyond time cursors to estimate peak to peak jitter, or multiple measurements and a calculator to determine rms jitter. Parameter measurement statistics provide direct reading jitter characterization. The optional 93XX-WP03 Parameter Analysis package extends this capability, providing histogramming and statistical parameters to automatically interpret the histogram data. Histograms provide a visual display of the statistical distribution of the measured parameters. Using the four traces available in LeCroy DSO's, it is possible to display up to 4 histograms or a source trace and 3 histograms.

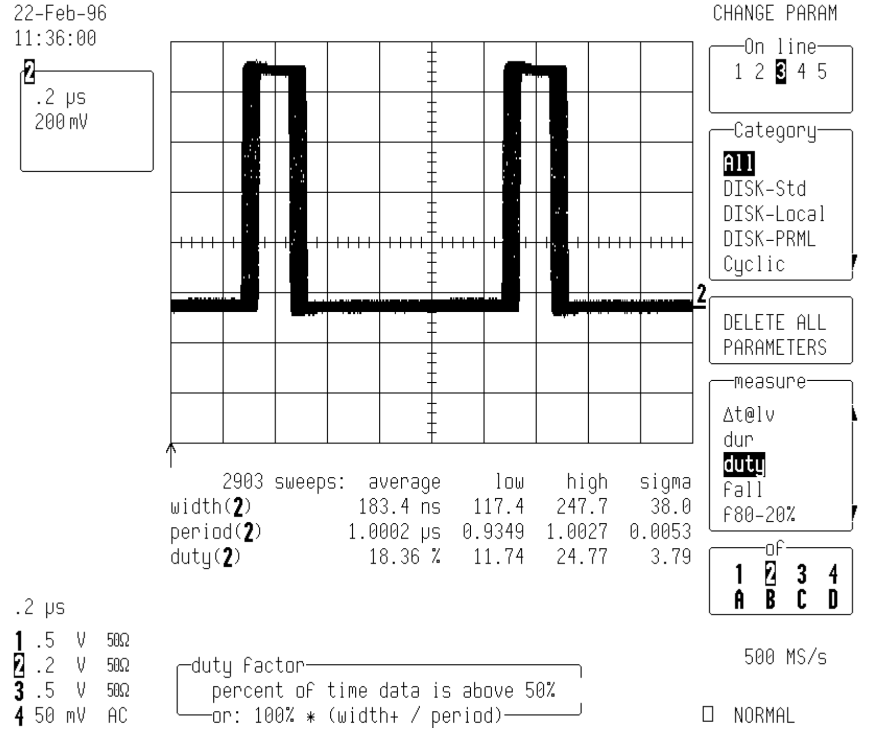


**Figure 1 - Direct readout of mean, low/high range, and standard deviation of width, period, and duty cycle measured over 2900 sweeps as shown in a persistence display**

Knowledge of the distribution of random processes like jitter is often of critical importance in understanding the source. An example is shown in figure 2 where the width jitter of a waveform is histogrammed.

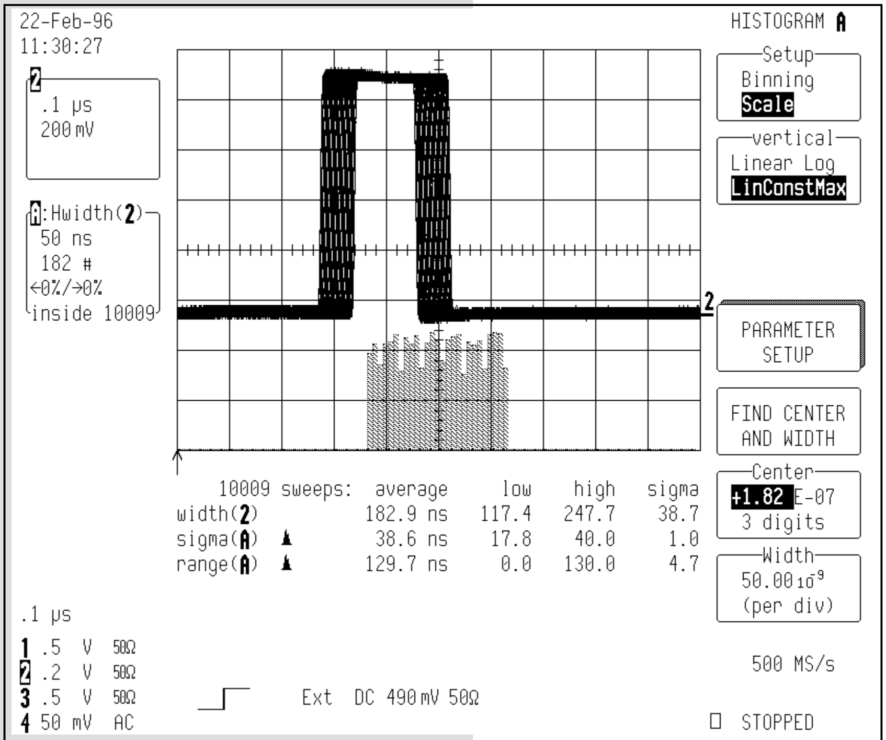


**Figure 2 -The histogram of the width parameter for 10,000 sweeps and direct readout of rms jitter , sigma (A), and peak to peak jitter, range (A).**

Note that in addition to the histogram display, the sigma (standard deviation) and range of the distribution are being readout as parameters. In this case, the jitter is uniformly distributed, i.e., any of the width deviations within the range are equally probable. Figure 3 shows the analysis of width jitter in which the jitter has a Gaussian distribution.

The uniform distribution is often associated with synchronization operations. The input waveform to a synchronizer selects the next available internal clock pulse. If the input and internal clocks are independent then the delay between the input and the clock is distributed uniformly over a clock period.

The Gaussian distribution is associated with random noise, which in figure 3, is associated with the phase noise in a reference oscillator.

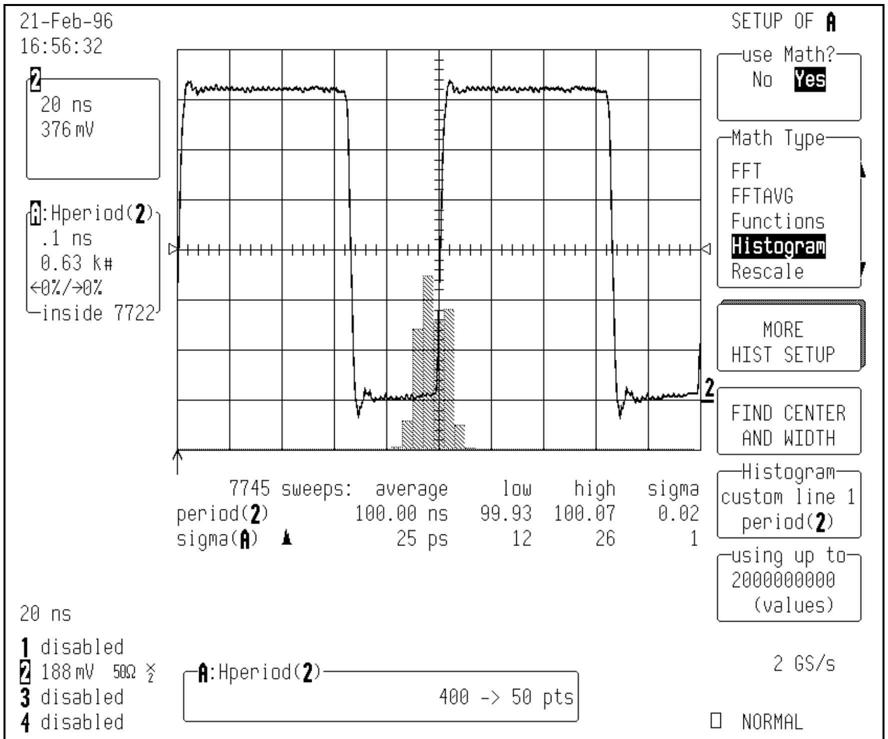


**Figure 3 - The histogram of width and direct readout of rms width jitter, sigma(A) and peak to peak jitter, range (A).**

The jitter contribution inherent in the oscilloscope measurement is due to several sources. These include trigger jitter, timebase stability, and delay jitter. In the 9300 series jitter due to the DSO is in the range of 10's of ps. This number can be minimized by using 0 delay, using a trigger signal with a high signal to noise ratio, and maximizing the measured waveform dynamic range by operating close to the full scale range of the selected Volt/Div setting. Since the DSO , or other measuring instrument, jitter sources are generally uncorrelated with those of the device under test they can generally be subtracted from the measured data using quadrature subtraction:

$$t_{DUT} = (t_{meas}^{\ 2} - t_{instr}^{\ 2})^{1/2}$$

Where :

**$t_{DUT}$** - jitter of device under test

**$t_{meas}$** - total measured jitter

**$t_{instr}$** - jitter due to instruments

The jitter due to instrumentation should be measured under the specific conditions of the test being performed. Parameter statistics and histograms make it easy as shown in figure 4. Here, for a delay measurement, the device under test has been replaced by a length of cable. Measuring the fixed delay of a cable shows the contribution from the test setup including the oscilloscope which is delay jitter of 28 ps rms .

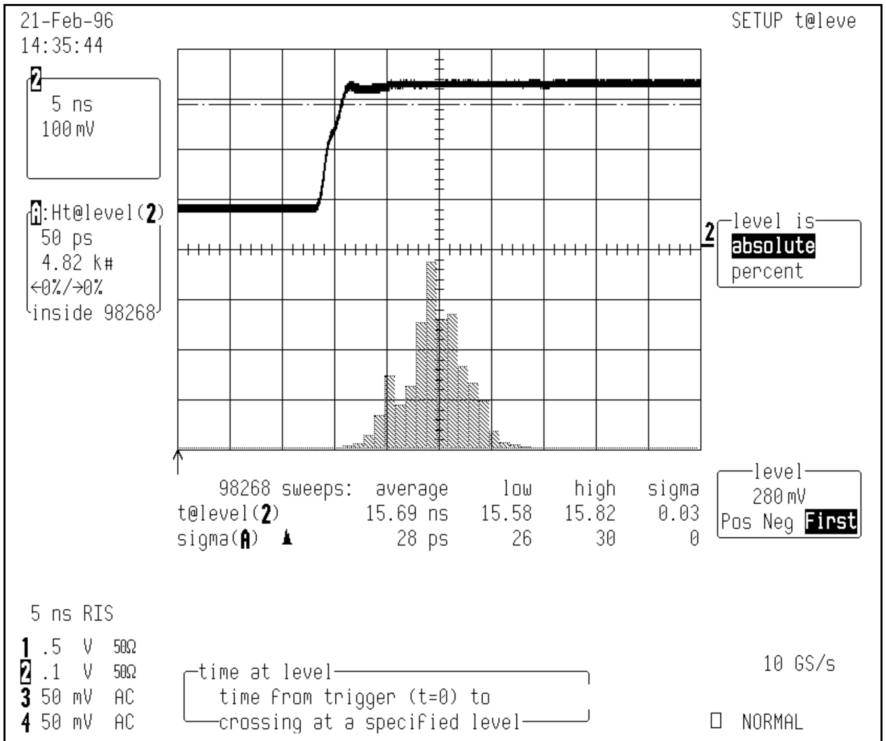


**Figure 4 - Time delay of a length of cable used to characterize the jitter due to the oscilloscope.**