Frequency Analysis Of Jitter

Frequency Selective Determination Of RMS Jitter

A common timing measurement requirement is to determine the rms jitter due to jitter components within a specified band of frequencies. This type of measurement can be made using the LeCroy Jitter and Timing Analysis (JTA) option combined with the oscilloscopes frequency domain analysis (FFT) tools.

Jitter in the time domain is manifested in the frequency domain as phase noise. The time interval error (TIE) function in the JTA option effectively measures the instantaneous phase of a signal and is a phase demodulator. The TIE output is a plot of signal timing variations relative to a user entered reference frequency, set to the carrier frequency in this application. The timing variations are plotted as a function of time. Applying the FFT to the TIE function results in a display of the spectrum of the phase modulation envelope.

Figure 1 shows the result of such an analysis. The top trace (ch2) is the acquired waveform. In this example it is a 10 MHz carrier phase modulated by a 100 kHz sine burst with a peak phase deviation of 0.1 radians. The acquisition is triggered by the modulation source and is synchronous with the 100 kHz burst.

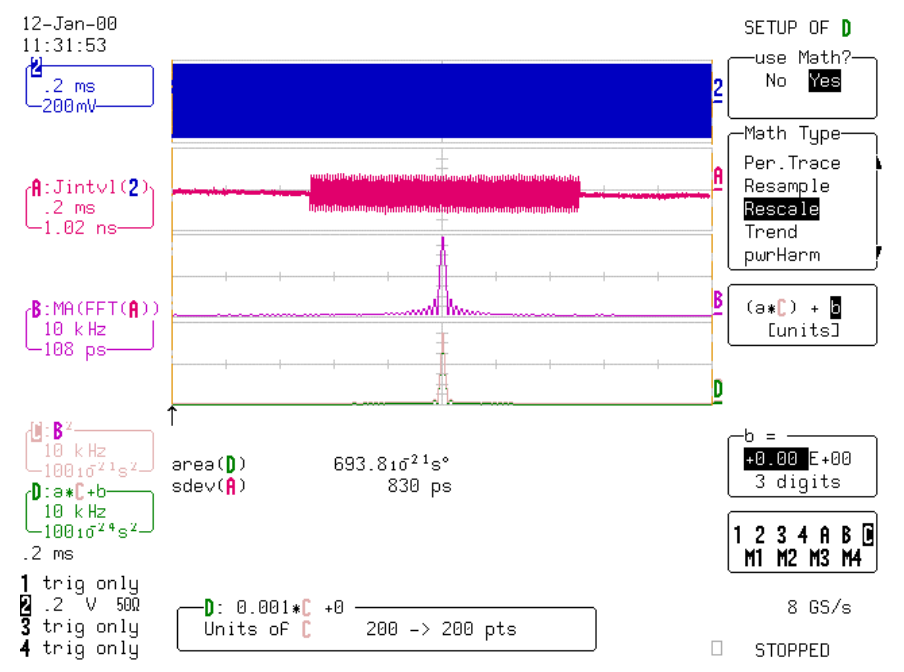

Figure 1– The mean squared (Area) and rms(sdev) jitter of a 10 MHz carrier modulated by a 100 KHz sine burst with a duty cycle of 50%.

The trace below the acquired waveform (trace A) is the time interval error of the acquired signal. Since this is the demodulated phase variation it effectively recovers the modulation waveform, in this case the 100 kHz sine burst.

The third trace from the top (trace B) is the FFT of the modulation waveform. The sine burst produces a distributed spectrum centered at the modulation frequency. The magnitude spectrum of the modulation envelope is read in units of time. This spectrum is squared (trace C) and then converted to a power spectral density by dividing the squared spectrum by the two times noise bandwidth of the FFT analysis. The noise bandwidth is the product of the resolution bandwidth of the FFT (Δf) and the effective noise bandwidth factor (ENBW) of the selected FFT weighting function. In this example we have chosen rectangular weighting with an ENBW factor of 1 and a Δf of 500 Hz. The factor 2 converts the FFT amplitude scale from peak to rms.

In trace D (overlapped with trace C) we use the rescale math function to divide the squared spec

trum by 1000. Trace D is the mean squared spectral density of the jitter waveform.
Our goal is to measure the rms jitter of the modulation spectrum in the frequency domain and to match that with the rms jitter of the time domain waveform.

The rms value of the time domain waveform, in trace A, is measured using the standard deviation (sdev) parameter. In this example it is 830 ps. The standard deviation is used instead of the rms value to eliminate the mean (DC) value which is of no interest in this example.

The area under the rescaled spectrum (traceD) is the mean squared value of the frequency domain waveform. The square root of the area parameter is the rms jitter of the frequency spectrum. The area is calculated between the parameter cursors which are placed at 0 and 10 divisions in this example. The mean squared spectrum has been expanded using display zoom and the area parameter is being calculated over a frequency range of 50 to 150 kHz. By using the parameter cursors and/or the zoom controls it is possible to select the frequency band of interest. In this example the rms value of the spectrum is 832.9 ps. This is within 0.3 % of the time rms jitter value of 830 ps.

The burst waveform was chosen because it produced a distributed spectrum with an rms value proportional to the square root of the duty cycle. In the first example the burst duration is 1 ms and the burst repetition period is 2 ms for a duty cycle of 50%. Table 1 shows the measured values of time (standard deviation) and frequency domain (√Area) jitter for duty cycles of 10% to 100%.

Duty Cycle %	Standard Deviation ps	√Area ps	Difference %
100	1,202	1,199	0.2
75	1,054	1,049	0.4
50	830	832.9	0.3
25	607	598.6	1.3
10	406	405	0.2

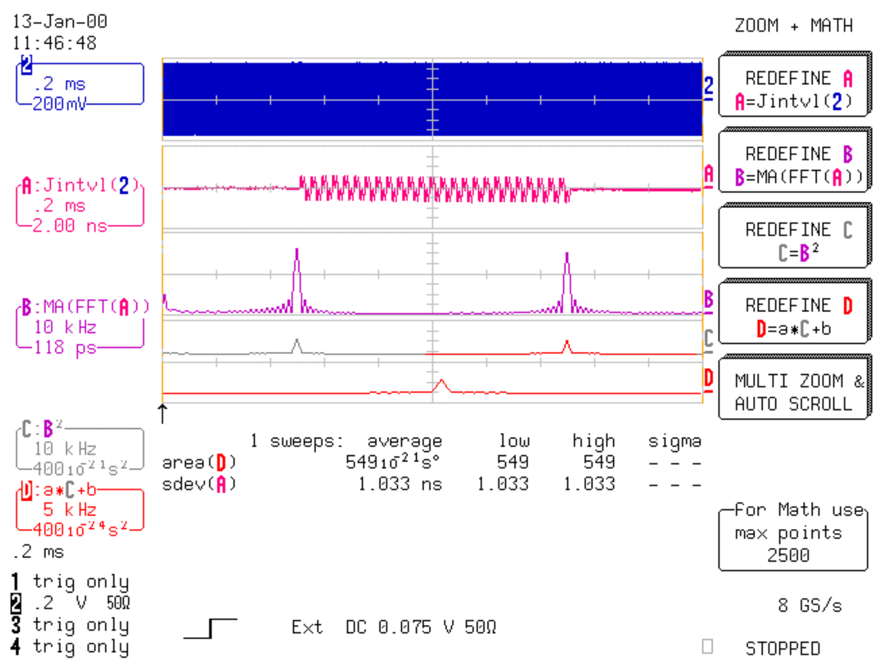

Figure 2 An example of separating jitter components of different frequencies

Repeated measurements of area and standard deviation indicate a variation of about 4% in the area parameter and 2 % in the standard deviation over multiple acquisitions.

Figure 2 shows how this technique can be applied to separate jitter components from different frequencies. A dual tone burst with 25 kHz and 75 kHz components is acquired. The total rms jitter is 1.033 ns rms, read using the standard deviation parameter. The jitter contribution from the 75 kHz burst is isolated using the display zoom. The square root of the area parameter reading (741 ps) is the rms jitter from spectral components in the range of 50 to 100 kHz.