Separating Jitter Sources

Frequency Selective Separation of Jitter Components

A common question often arises concerning jitter measurements. If I remove a jitter component from the jitter spectrum, how will that impact the overall timing jitter? This question can be answered using the LeCroy J-260 Jitter Analyzer.

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.

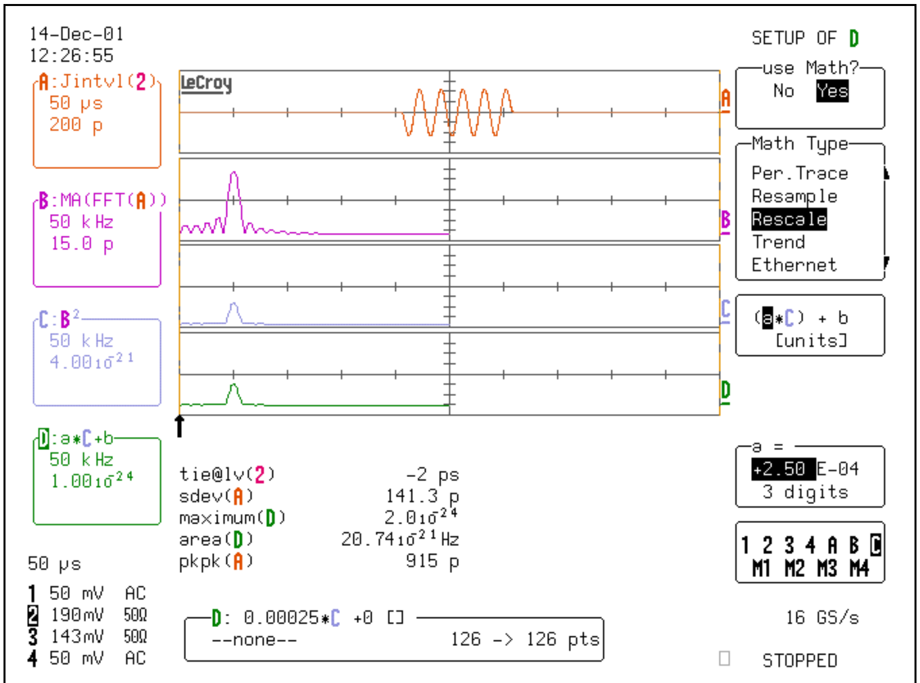

Figure 1– The mean squared (Area) and rms(sdev) jitter of a 400 MHz carrier modulated by a 50 KHz sine burst with a duty cycle of 20%.

Figure 1 shows the result of such an analysis. The input signal (ch2) is a 400 MHz carrier phase modulated by a 50 kHz sine burst with a peak phase deviation of 1.14 radian. The acquisition is triggered by the modulation source and is synchronous with the 50 kHz burst.

The top trace (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 50 kHz sine burst.

The second 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 2000 Hz. The factor 2 converts the FFT amplitude scale from peak to rms.

In trace D we use the rescale math function to divide the squared spectrum by 4000. 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 141 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, 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 0 to 200 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 144 ps. This is about 2 % of the time rms jitter value of 141 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 100µs . and the burst repetition period is 0.5 ms for a duty cycle of 20 %. The theoretical rms jitter for a 1.14 radian peak phase deviation and 20% duty cycle is 143 ps

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 three tone signal with 30 kHz, 62.5 and 95 kHz components is acquired. The total rms jitter is 199 ps rms, read using the standard deviation parameter. The jitter contribution from 0 to 77 kHz is isolated using the parameter gating cursor. The square root of the area parameter reading ,30.1 10^{-21}, yields173 ps rms jitter from spectral components in the range of 0 to 77 kHz. Figure 3 shows a confirmation of this value based on removing the 95 kHz

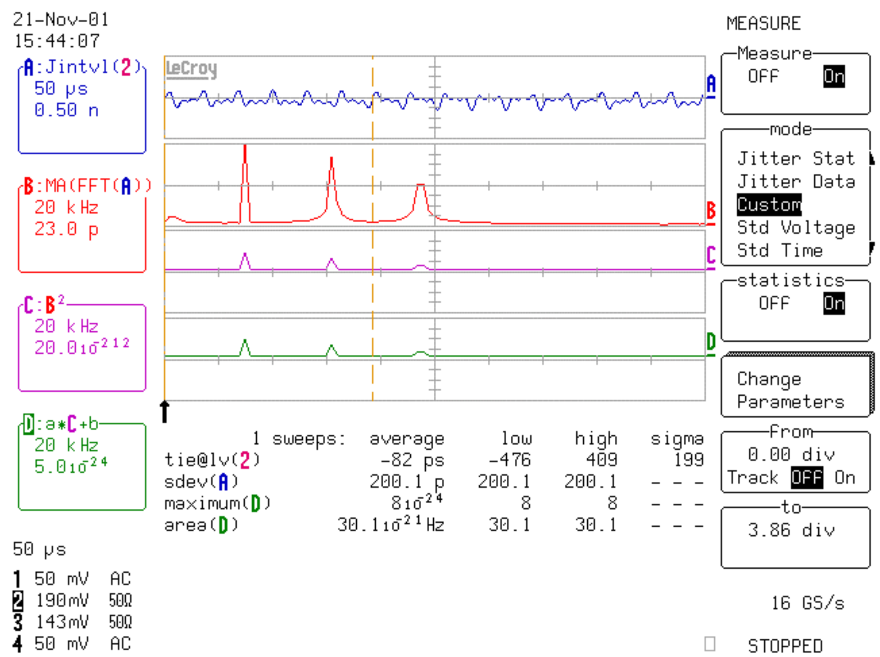

Figure 2 measuring the contribution of the spectral components between 0 and 77 kHz to the total rms jitter. The square root of area is equal to 173.5 ps.

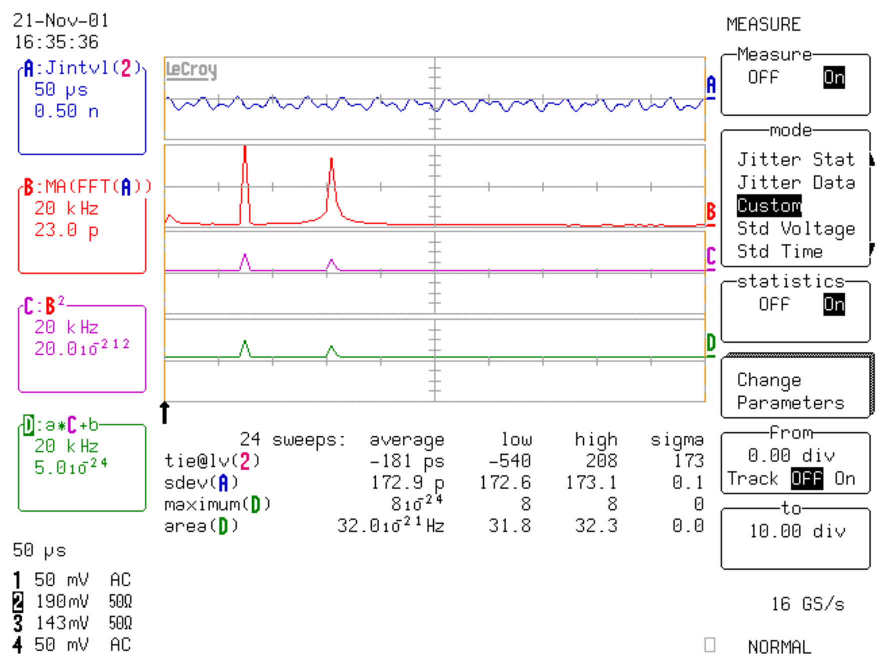

Figure 3 The sigma of TIE confirms 173 ps rms jitter without the 95 kHz component

component from the source waveform.