NEL's Wavecrest Standard Test

Procedure #202
How to Measure Jitter in Crystal Clock Oscillators

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Purpose

Jitter is noise in a system that distorts the signal (wave forms) used to communicate between components on a board. These distortions will cause timing errors which impact a system's bit error rate (BER) and reduce a network's overall reliability. Jitter affects the entire system so it is necessary to understand the jitter introduced by each element in order to accurately predict the performance of the system. In order to quantify the jitter created by a crystal clock oscillator, it is necessary to measure characteristics of a series of wave forms, including the transition point from cycle to cycle.

Tests to Measure Wave Forms

1. Total Jitter (TJ): 1 sigma and peak to peak

Jitter is defined as the deviation of a timing event in a signal from its ideal position. Jitter affects the entire system and can be introduced by any element in the circuit used to generate, convey or receive signals. The total jitter (TJ) of a system is the combination of the probability density functions of the random jitter (RJ) and the deterministic jitter (DJ).

2. Random Jitter (RJ): RMS (1 clock period and N clock periods)

Random jitter can be described by a Gaussian distribution and it is assumed that it is unbounded. Because the random jitter is Gaussian, the distribution can be quantified using the standard deviation (sigma) and the mean. Random jitter is commonly caused by the movement of electrons and holes in a semiconductor, by carrier density fluctuations as a result of the random capture and emittance of electrons from oxide interface traps or by the energy transfer between free electrons and ions in a conductor.

3. Periodic/Deterministic Jitter: Peak to peak (1 clock period and N clock periods) at any given modulation frequency peak

Deterministic jitter (DJ) is characterized by the bounded peak to peak (pk-pk) amplitude. There are several types of deterministic jitter, including duty cycle distortion and intersymbol interference, both of which are data dependent types of jitter, as well as periodic jitter (PJ), also called sinusoidal jitter. Periodic jitter is characterized by a signature that repeats at a fixed interval and can be quantified as a pk-pk number, specified with a frequency and magnitude. A cause of periodic jitter could be unwanted modulation, like electromagnetic interference.

Note: Any frequency bandwidth of the modulation frequency can be applied from very low frequency to Nyguist for PJ and RJ

4. Bathtub curve for bit error rate

Equipment

1. Wavecrest Advanced Clock Test Set Model DTS-2075. The Wavecrest Test Set provides an 800 fsec resolution.
2. Low noise power supply.
3. Good RF fixturing refer to NEL Technical Paper “Low Jitter, Low Emission Timing Solution to High Speed Digital Systems” posted at www.nelfc.com.

Setup Procedure

1. Solder the oscillator to the fixture or the board, with the output connected directly into the Test Set.
2. The Test Set distance should be minimized (less than one inch) from the fixture.
3. Use good RF filtering to decouple the power source to filter out power supply noise at all frequencies along with an adequate ground plane.
4. The test point is coaxial connector on the output to connect to the Test Set.

Procedure

1. Once test set-up is complete, allow over 5 minutes for crystal oscillator to warm up before measurements are taken.
2. Allow measurement of jitter to exceed 2000 cycles, which is statistically significant.
3. Review frequency information in the High Frequency modulation window and minimize any frequencies from sources other than the oscillator under test.

Warnings and Considerations

1. Scope probes that scale down the wave form by 5x or more interfere with the results.
2. A distance beyond one inch between the Test Set and fixture increases the likelihood of additional jitter outside the crystal clock.
3. When measuring jitter, it is critical that system jitter unrelated to the crystal oscillator be minimized.