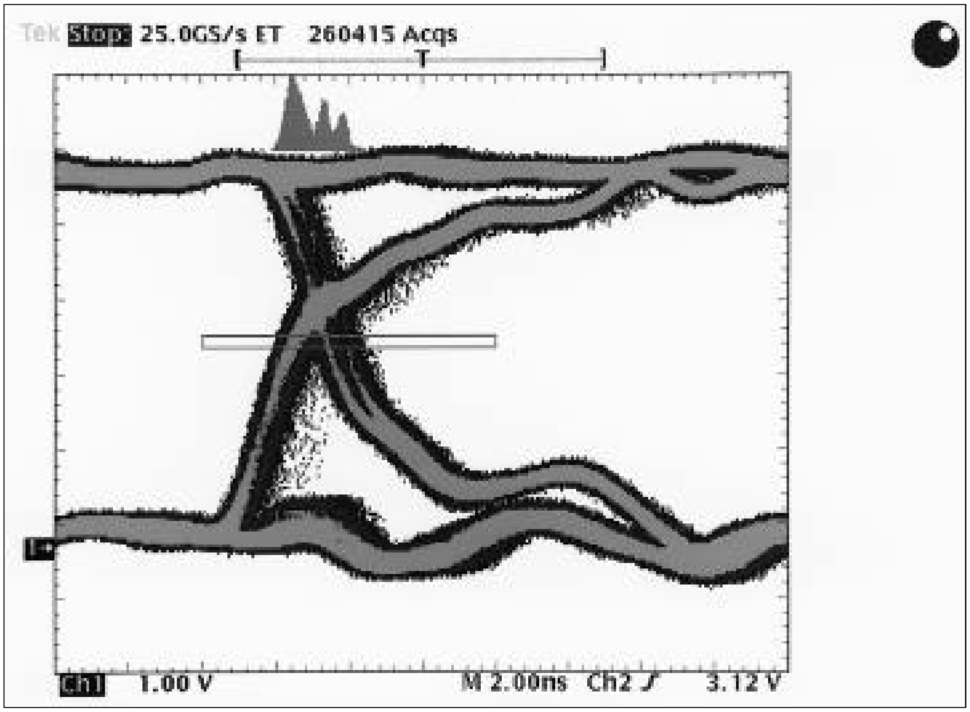
Tektronix

Application Note

Performing Jitter Measurements With The TDS 700D/500D Digital Phosphor Oscilloscopes



The DPO can show the extent of edge jitter, then present a histogram quantifying the distribution of the signal.

Introduction

As clock speeds increase and timing margins continue to decrease, engineers in the communications and semiconductor industries have a greater need to measure jitter in their systems. Excessive jitter can increase the BER (bit error rate) of a communications signal by incorrectly transmitting a data bit stream. Jitter in a digital system can violate timing margins, causing circuits to behave improperly. Careful characterization of jitter will determine the robustness of a system and how close it is to failing.

Measurement System Jitter

The oscilloscope test system can add jitter to the device under test. These error parameters include amplifier vertical noise, sample clock jitter, quantization error, trigger jitter, and interpolation error. Figure 1 shows a TDS 784D measurement of a single rising edge. The standard deviation (sigma) of the jitter shown by the histogram is 5.7 ps. The scope measurement also shows that 100% of the points fall within ±3 sigma of the mean. This statistic is further supported by the peak-to-peak jitter measurement of 32 ps.

Statistical confidence in measurements increases with

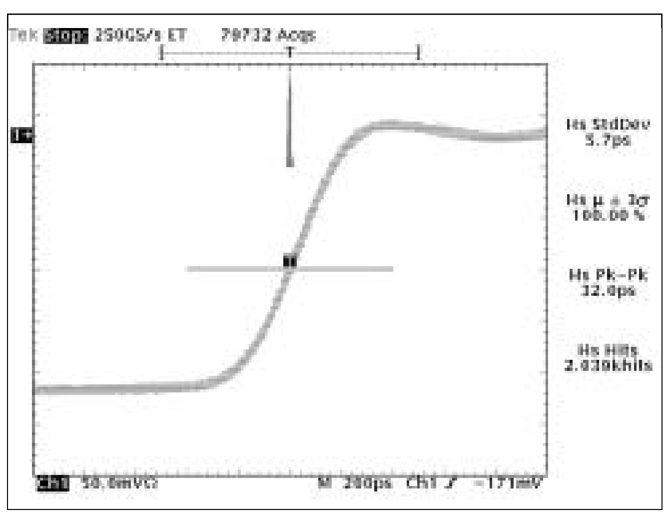


Figure 1. Oscilloscope system jitter.

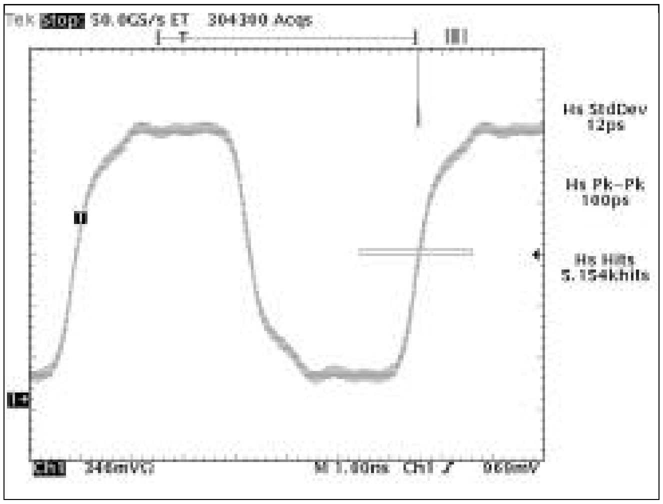


Figure 2. Cycle-cycle jitter

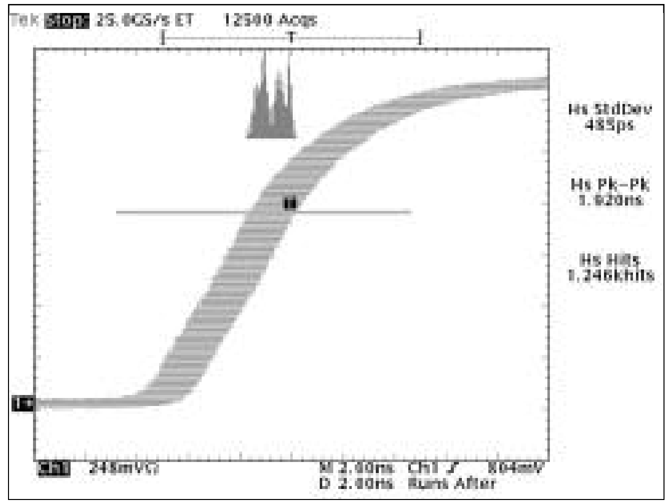


Figure 3. Long-term jitter.

sample points collected. In this example, 79,732 acquisitions were acquired, providing 2,039 data points to determine the statistics. The TDS 784D Digital Phosphor Oscilloscope with the 3D Database can collect statistical information at a rate of 25 million samples/second, considerably improving the confidence of a statistical measurement.

Cycle-Cycle Jitter

After the jitter performance of the oscilloscope is understood, jitter measurements can be made with the oscilloscope. Cycle-to-cycle jitter is commonly defined to be the deviation of one rising (or falling) clock edge to the next rising (or falling) edge. Figure 2 shows a TDS 784D performing a cycle-to-cycle jitter measurement. The standard deviation (sigma) is 12 ps. Assuming a Gaussian distribution, Table 1 shows the confidence for various values of sigma from a probability table.

Table 1. Probability Table

Sigma	Probabilities (double-sided)
1	68.26%
2	95.45%
3	99.73%
4	100% – 6.334 x 10^{-3}% = 99.993666%
6	100% – 1.973 x 10^{-7}%
8	100% – 1.244 x 10^{-13}%
10	100% – 1.524 x 10^{-21}%

We have a 4 sigma or 99.993666% confidence level at ±12 ∗ 4 ps = ±48 ps. For a 10 sigma confidence level, the jitter performance can be specified to 12 ∗ 10 = ±120 ps.

Assuming random sources of jitter:

$$Jitter_{Cycle\text{-}to\text{-}Cycle} = \sqrt{\quad}$$

Long-Term Jitter

Another common jitter measurement is accumulated or long-term jitter. This is defined to be the deviation of a rising (or falling) edge “n” cycles after the first rising (or falling) edge. Figure 3 shows a TDS 784D measuring the n = 100th cycle of a 10 kHz clock. The scope is set to delay by 10 ms (n ∗ period of 10 kHz clock). This is the long-term jitter performance of the 10 kHz clock over 100 cycles or 10 ms. If the jitter spec is ±1.5 ns, the measured peak-to-peak jitter of 1.92 ns handily meets the spec. However, this limit is approximately 3 sigma from the mean and has a 0.27% chance that the clock will fail the jitter spec on every edge. This translates into a failure every 370th edge of the clock.

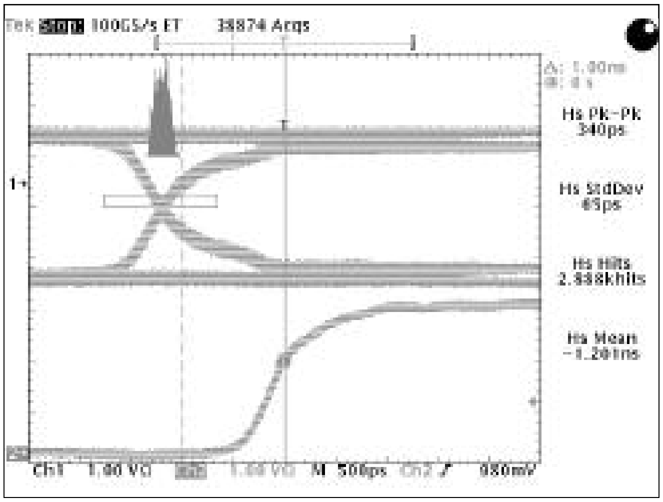


Figure 4. Edge-to-edge jitter.

Edge-to-Edge Jitter

Figure 4 shows a typical edge-to-edge jitter measurement. This could be a set-up and hold measurement or a skew jitter measurement between two synchronous outputs of a microprocessor; assume that this is a data-to-clock set-up time measurement. The minimum set-up time of 1 ns is shown between the two vertical cursors. The standard deviation of the data signal is measured to be 65 ps, with a mean of –1.201 ns. For a 6 sigma confidence, the mean of the data signal would need to be at –1.39 ns (–1 ns – 6 ∗ 65 ps). There's only approximately 3 sigma between the mean of the data signal and the minimum set-up time (dotted vertical cursor). This is inadequate margin to always guarantee that the set-up time will not be violated. Even at 6 sigma, a 1 GHz signal would fail every 500 ms.

Conclusion

Jitter measurements are critical in characterizing the robustness of your system. Before making any jitter measurement, determine the inherent jitter in your measuring device by using a very stable reference oscillator.

Jitter measurements are also statistical in nature. As a result, peak-peak measurements are sometimes not as effective as using statistical techniques to predict jitter. The 3-D Database DPO (Digital Phosphor Oscilloscope) rapidly accumulates waveforms and generates greater confidence in the peak-peak measurement. Couple this with the statistical analysis capabilities of the DPO oscilloscope, and you have a very effective jitter analysis tool.

For further information, contact Tektronix:

World Wide Web: http://www.tek.com; ASEAN Countries (65) 356-3900; Australia & New Zealand 61 (2) 888-7066; Austria, Eastern Europe, & Middle East +43 2236 8092 0; Belgium +32 (2) 715.89.70; Brazil and South America 55 (11) 3741-8360; Canada 1 (800) 661-5625; Denmark +45 (44) 850 700; Finland +358 (9) 4783 400; France & North Africa +33 1 69 86 81 81; Germany + 49 (221) 94 77 400; Hong Kong (852) 2585-6688; India (91) 80-2275577; Italy +39 (2) 25086 501; Japan (Sony/Tektronix Corporation) 81 (3) 3448-3111; Mexico, Central America, & Caribbean 52 (5) 666-6333; The Netherlands +31 23 56 95555; Norway +47 22 07 07 00; People's Republic of China 86 (10) 6235 1230; Republic of Korea 82 (2) 528-5299; South Africa (27 11)651-5222; Spain & Portugal +34 (1) 372 6000; Sweden +46 (8) 629 6503; Switzerland +41 (41) 729 36 40; Taiwan 886 (2) 722-9622; United Kingdom & Eire +44(0)1628 403400; USA 1 (800) 426-2200.

From other areas, contact: Tektronix, Inc. Export Sales, P.O. Box 500, M/S 50-255, Beaverton, Oregon 97077-0001, USA 1 (503) 627-6877.

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