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DESIGN NOTES

High Speed Digital Notes from the *HFE* Archives:

Since our inaugural issue in July 2002, well over 500 technical articles, reports, product features and editorial columns have been placed in the *High Frequency Electronics* online archives. These articles cover a wide range of topics—power amplifiers, filters, modulation, system specifications, wireless standards, etc. An area of special attention is high speed digital design. This note includes some key points from one of our extended (three-part) articles.

Understanding, Measuring & Eliminating Jitter

Jitter—deviations in the timing of digital signals—is a key issue in high speed circuits. A series of articles in 2004 [1, 2, 3] provided fundamental information on jitter that is still current today.

The first article focused on defining jitter and its characteristics, which is what we'll review here. First, there are two types of jitter:

Cycle-to-Cycle Jitter—The time difference between successive periods of a signal.

Period Jitter—An RMS calculation of the difference of each period from the average.

Both types describe jitter as some deviation from a signal's ideal location in time, e.g., whether rising/falling edges are early or late relative to a perfectly timed signal.

Some of these deviations are apparent in the accompanying figure, showing an imperfect eye diagram. The differences between this diagram and the smooth, even transitions of an ideal eye diagram can help identify many signal problems, including jitter.

Sources of Jitter

Where does jitter come from? There are several areas where jitter can arise:

1. System phenomena

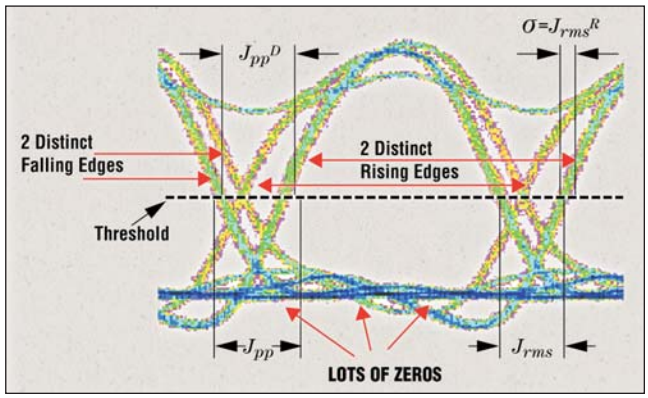
Effects that arise from analog transmission of a digital signal waveform:

- Crosstalk from radiated or conducted signals
- Dispersion effects
- Impedance mismatch

2. Data-dependent phenomena

Patterns of data streams can affect the net jitter in the received digital signal:

- Intersymbol interference
- Duty-cycle distortion
- Pseudorandom, bit-sequence periodicity



An eye diagram with an irregular shape provides a wealth of information (1).

3. Random noise phenomena

Physical characteristics that randomly introduce noise into an electronics system:

- Thermal noise—*kTB* noise
- Shot noise—electron noise in semiconductors
- "Pink" noise—classic 1/*f* noise

Building from these basics, this article series provides details on jitter measurement methods, test equipment choices, standards-based test procedures, and evaluation of "measurement floor," or minimum jitter measurement capability.

Finally, the author addresses the troubleshooting process, with the objective of identifying and eliminating jitter. In particular, the ability to correlate jitter with specific events is extremely important. Test signals, multi-channel data monitoring, and identification of a distinctive "signature" of some types of jitter all can help find the cause. Once isolated, each contributing problem area can be addressed to reduce its jitter contribution and improve system performance.

References

These articles are available online. Click on the "Archives" tab at: www.highfrequencyelectronics.com

1. Johnnie Hancock, "Jitter—Understanding it, Measuring it, Eliminating it, Part 1: Jitter Fundamentals," *High Frequency Electronics*, April 2004.

2. Johnnie Hancock and Steve Draving, "Jitter—Understanding it, Measuring it, Eliminating it, Part 2: Jitter Measurements," *High Frequency Electronics*, May 2004.

3. Johnnie Hancock, "Jitter—Understanding it, Measuring it, Eliminating it, Part 3: Causes of Jitter," *High Frequency Electronics*, June 2004.