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It's Not the Same Old PCB Anymore

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Signal integrity (SI) engineering is difficult to avoid in current electronic systems. It is needed now more than ever to save time and money, and to enable the design to work reliably. This white paper discusses the necessity of SI analysis as well as some of the SI analysis methods used by the author.

Is Signal Integrity Analysis Really Required?

I/Os and printed circuit boards have to be simulated to see what is going on inside. Nothing behaves in a linear manner. Silicon has corners, and based on the rise and fall times and the particular layout of the board, a different answer is obtained for every output flavor and trace. Having no tool to simulate the SI of a design is like living in Los Angeles and not driving a car.

Is There No “Public Transportation”?

There is no easy way to avoid buying and using a signal integrity simulation tool. Before there was the SPECCTRAQuest tool by Cadence Design Systems, or the HyperLynx or ICX tools by Mentor Graphics (as well as other popular tools), what did the signal integrity engineer do?

At the beginning of this issue in 1971, transmission line and termination problems were solved with emitter coupled logic (ECL) using paper and pencil. The printed circuit board had to be correct by construction, which was not hard to do because materials, dimensions, and impedance were easily hand-calculated.

Connectors were a bit more difficult because there were no easy ways to model them. The time domain reflectometer (TDR) was used to solve a double-clocking problem in ECL at 300 MHz data rate with a forward error corrector. However, TDR could only be used to identify problems after the board was built. Designs took from three to five printed circuit board iterations (“turns” or “respins”) to become perfect.

To save time, money, and engineering effort, a set of math simulations was developed using the Mathcad tool by PTC (formerly Mathsoft). Johnson and Graham’s *High Speed Digital Design* [Ref 1] reinforced that approach with many Mathcad program examples in the appendices.

Mathcad is not free, and neither is the TDR. A lot of time was also spent doing the analysis. The boards were not perfect, but the number of turns was brought down to two, or occasionally three.

Summary

One would not try to assemble a surface-mount component board with a soldering gun or adjust one’s engine timing with only a screwdriver. Similarly, to use the integrated circuits available today (SRAMs, DRAMs, ASICs, ASSPs, microprocessors, and FPGAs), one must also use the right tools for the job. As an example, HyperLynx shows far more detail than a more expensive oscilloscope, and it can probe nodes that could never be physically reached.

References

This white paper references the following publication:

1. Johnson, Howard, and Martin Graham. 1993. *High Speed Digital Design: A Handbook of Black Magic*. Prentice Hall.

Revision History

The following table shows the revision history for this document:

Date	Version	Description of Revisions
03/27/08	1.0	Initial Xilinx release. Based on a previously-published *Tech Xclusive* article by the same author.

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