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# CHAPTER 18
# Signal Integrity

Getting high-speed digital signals to function properly is one of those areas that many people call *black magic*. It is so called, because fast digital signals behave like the analog signals that they really are, which is not an apparent mode of operation from a binary perspective. The typical story of woe is one in which a digital engineer continues to design faster circuits in the same way as slower circuits, and one day a system begins developing unexplained glitches and problems. From a digital perspective, nothing substantial has changed. On closer inspection with an oscilloscope, individual digital signals have mysterious transients and noise superimposed on them.

*Signal integrity* is the overall term for high-speed electrical design techniques that enable digital signals to function digitally in the face of physical phenomena that would otherwise cause problems. Many of the terms and techniques introduced in this chapter may sound familiar, because they have received increased scrutiny and coverage in the trade press and at conferences as a result of the steady increase in semiconductor operating frequencies. Signal integrity used to be a topic that many systems could ignore simply by virtue of their older technology and slower signals. That luxury has largely evaporated today, even for slow systems that unwittingly use ICs designed for high-speed operation.

A broad set of topics are discussed in this chapter with the goal of providing familiarity with signal integrity problems and general solutions to those problems. Transmission lines and termination are absolutely critical interrelated subjects, because they literally make the difference between working and nonworking systems. Transmission lines address head-on the reality that wires have finite propagation delay and are not ideal transparent conductors that ferry signals from point to point unchanged. From a purely functional perspective, proper transmission line analysis and design is the most important part of signal integrity, which is why these topics are presented first.

High-speed signals exist in a world of non-negligible electromagnetic fields that cause even small wires to act as antennas. These antennas are capable of both radiation and reception of noise. Crosstalk, electromagnetic interference, and electromagnetic compatibility are associated topics that hinge around the reality that electrical signals do not remain neatly confined to the wires on which they travel. The problems are twofold. First, excessive field coupling can cause a circuit to malfunction. Second, electronic products offered for sale in most countries of the world must comply with government regulations regarding their electromagnetic emissions. You don't want to bring home a new DVD player to find that it crashes your computer when you turn it on!

The chapter concludes with another related topic, electrostatic discharge. Static electricity is something that we are all familiar with, but its effects on a digital system are potentially disruptive and even destructive. Static electric discharges cannot be prevented in normal environments, but their effects can be reduced to the point of not causing problems.