# Everyone Needs to Understand High Speed Digital Design Techniques

From September 2006 *High Frequency Electronics*


As the digital portion of electronic equipment gets closer to the antenna, there is a corresponding need for traditional "RF engineers" to understand digital design techniques. Whether or not they are involved in the design of the actual digital circuitry is unimportant—whatever part they are working on will eventually interface with the digital part.

Analog and digital performance are interdependent. Linearity of analog circuits affects the accuracy of the data being transmitted. Bit rate, symmetry of the bit stream and the specific coding of the digital signal can affect the performance of analog circuits, and certainly establishes their required performance.

These things are well-known in many companies that specialize in the design and manufacture of equipment that uses both digital and analog circuitry. Wireless handset and base station equipment, military communications, satellite systems, fiber optic transmit/receive interfaces, and test instruments are the most common examples of such products. But the need is expanding to include nearly all designers of high frequency electronic equipment.

Some of the simplest inexpensive consumer gadgets use digital modulation to transmit a data stream, rather than sending an analog signal as was the case for many years. Even in remote control toys, microprocessors replaced tone decoders a number of years ago. Most "voice" communication is transmitted digitally with the only analog signals being the input audio to the CODEC and the final few stages before the antenna.

## Key Areas of Design

Fundamental digital communications is an essential area of knowledge. The earliest uses were telemetry, then microwave relay and satellite communications. Many textbooks from this era actually did a good job of describing the issues of analog-to-digital and digital-to-analog conversion, coding schemes, sampling theory, timing requirements and other system-level fundamentals.

Circuit-level implementation of these principles could be found in application notes for integrated circuits (and board-level modules) designed for digital systems. The main issues in the transmission path were echo-cancelling of reflections in wireline systems, multipath in point-to-point microwave systems, and error correction methods to compensate for unpredictable transmission impairments.

## Current Issues in Digital Circuits and Systems

The basic factors just noted are also part of any current design, but their effects have been multiplied by higher data rates, the need for low error-correction overhead to better reach "real time," wider bandwidths and more complex modulations to pack more data into each channel. With many more digital systems operating, interference is now a major factor, as are multipath effects in cluttered environments and with mobile transmitters and receivers.

At the circuit level, early analog-digital interfaces were at baseband—tens of MHz. Today, that interface might be at IF—a couple hundred MHz—or even at the front end, following a channel filter at the input. These high frequencies represent an overlap of the RF/microwave digital circuit functions, e.g., the input of an analog-to-digital converter (ADC) must perform as a low noise amplifier or buffer. The output of a digital-to-analog converter (DAC) is also an IF amplifier or pre-driver.

A designer also needs to know the requirements on the digital side. Gain, noise figure and dynamic range have more significance when the output is to be digitized by an ADC. The DC threshold and voltage swing of the output waveform are significant factors that are rarely critical parameters in an all-analog system. The following article on ADC buffers (starting on page 38) addresses this specific design issue with greater detail.

With digital systems, self-interference can be a significant new issue for analog designers. This involves mainly crosstalk and clock-related spurs, but requires new awareness of power supply decoupling, physical circuit layout and the distribution of timing signals to multiple boards, or multiple devices on a single board. A digital bit train represents a fundamental and its harmonics, with the fundamental having an amplitude measured in volts, not milli- or microvolts!

## Who Needs to Know?

The engineers who need to know these things have already done so, and continue to learn. This short report may be considered a reminder to their colleagues who have not yet been required to work directly with digital systems down to the circuit level. Much has been written on the need for digital engineers to understand high frequency analog principles; this is the complementary reminder that there is plenty for analog engineers to learn about digital circuits, as well.