Chapter V

A/D Conversion Applications

Godi Fischer
University of Rhode Island, USA

INTRODUCTION

The microelectronic (r)evolution that took place over the last four decades has influenced many domains of our daily life. It certainly left its footprints in the field of analog-to-digital and digital-to-analog conversion (ADC and DAC). Compared to the mind-boggling progress in the area of digital system integration, however, the performance improvements in ADCs and DACs seem relatively modest. There exists a good reason for this. Data converters form the very interface between the physical (analog) world and the digital world and thus have to cope with many adverse effects and limitations of the real world, such as component value tolerances, finite amplifier settling times, nonlinear device characteristics, clock jitter, component noise, etc. Therefore, no matter how sophisticated a system one devises, the performance of DACs and ADCs (assessed in terms of resolution and conversion rate) will always be limited by a physical deficiency of a device or element. The analog designer is faced with the task of approaching this physical barrier as closely as possible without exceeding given constraints (e.g., circuit size, power dissipation, manufacturing cost). Of course, the digital world has its limitations, too. A major limiting factor in a digital system is processing speed. Speed is directly related to the propagation delays of the constituent building blocks. In monolithic circuits, these delays are highly dependent on the feature size of the implementation process. As far as processing accuracy is concerned, however, the only limit is the available silicon real estate, or the number of components that can be fabricated reliably on a single chip. The component density continues to grow exponentially, an observation we have become so accustomed to that we refer to it as Moore’s Law. Currently, the number of transistors per chip doubles about every eighteen
months. To fully grasp the impact of this ‘law,’ let us recall that the first microprocessors, which appeared in the early 1970s, comprised not more than a few thousand transistors, while state-of-the-art processor chips house in excess of ten million devices. In addition, all internal operations of the latest vintage processor are carried out at a clock rate, which is approximately a thousand times higher. This means that any recently fabricated microprocessor outperforms its earliest ancestor, which is barely thirty years old, by more than a factor of a million! This is indeed an astounding achievement. To take advantage of this continuing trend towards denser and faster digital circuits, the ADC/DAC designer must aim at keeping the number of analog system components at a minimum and try to improve the system performance by exploiting the speed and density of digital circuitry. Good examples of this design philosophy are data converters that employ digital error correction schemes or oversampled, noise-shaping converters that require extensive digital filtering. ADCs and DACs based on delta-sigma modulation are among the best-known members of this group of digitally enhanced data converters. We will therefore pay special attention to this particular approach.

The trend of shifting more and more tasks to the digital domain implies that ADCs and DACs are increasingly used as macro-cells embedded in large mixed-signal systems rather than standard discrete parts used for board level assembly. This requires (future) designers of data converters to be well versed in the analog as well as the digital world.

We begin our excursion into the field of data conversion by reviewing the most frequently applied conversion principles. The next section explains the fundamentals of delta-sigma modulation. This paves the way for the section which provides a case study of a delta-sigma based high-resolution ADC system intended for a sonar application. This design example not only illustrates the various trade-offs on the architectural level but also addresses practical implementation issues on the physical level. Finally, the last section summarizes our findings and contains some concluding remarks.

**DATA CONVERSION PRINCIPLES**

Before we review the various ADC principles and discuss their characteristics and limitations, let us assume the perspective of a system designer. An ADC represents a discrete time system. Consequently, its output spectrum will be periodic. To avoid aliasing, the input signal must therefore be band-limited to half the sampling rate (Nyquist rate). If the analog input features frequency components close to the Nyquist rate, the necessary continuous-time pre-filter must be very selective and can significantly contribute towards the system cost. Conversely, if one operates the converter signifi-
Evaluating the Understandability of Android Applications
www.igi-global.com/article/evaluating-the-understandability-of-android-applications/191208?camid=4v1a