Analog to Digital Conversion Technology

Introduction

Analog to Digital Converters (ADCs) are the essential parts in interfacing the digital domain with the analog world to bring the power of computation to a range of tasks. Audio processing, photograph and video manipulation, and biomedical instrumentation are a small sample of the areas that have been advanced due to the application of computation. This paper is a review of ADC technology. It reviews a variety of ADC architectures, the tradeoffs associated with each one, and describes typical applications of each architecture.

Successive Approximation Register Architecture

The Successive Approximation Register (SAR) is a typical ADC architecture. This architecture works by comparing the input signal to a voltage generated by a digital-to-analog converter (DAC). This generated voltage successively steps closer to the signal voltage, each step gaining one bit of accuracy [1]. Unlike the Delta-Sigma architecture discussed below, which uses a digital filter, the SAR ADC is independent of any previous activity [2] and has low latency between receiving a sample request and producing a sample [3]. These properties make this architecture good for one-shot, burst, and multiplexed operations, [2] and for control systems with consistent loop time [3] The SAR ADC is capable of sampling rates, resolutions, and signal-to-noise ratios that are between the other two ADC architectures described in this paper. The ADS8422 ADC produced by Texas Instruments, priced at \$25.63 per unit (retrieved Oct 24, 2017 from the TI website), is an example of a high-end SAR ADC. This chip is capable of 16 bits of resolution, a 4 megasamples per second (MSPS) sampling rate, and a signal-to-noise ratio

of 90 dB at 500 kHz. Suggested applications of this device include data acquisition, medical instruments, and spectrum analysis [4].

Delta-Sigma Architecture

The Delta-Sigma architecture is another common ADC architecture. An integrator, comparator, 1 bit DAC, and summation block produce a bitstream with a ones density that corresponds to the level of the input signal. A block diagram of this architecture is given in [1] on page 3.111. A digital filter converts this bitstream into a digital value [1]. The high resolutions that Delta-Sigma ADCs are capable of makes them good for sensing bridge and thermocouple transducers, and for industrial measurement . The high input sampling rate and high resolution also makes this architecture good for audio applications [2]. Delta-Sigma architecture ADCs generally have higher resolutions, higher signal-to-noise ratios, and lower data rates than ADCs with other architectures. The ADS1278-EP produced by Texas Instruments, priced at \$35.78 (retrieved Oct 24, 2017 from the TI website), is an example of a high-end Delta-Sigma ADC. This chip has eight sampling channels, each capable of 24 bits of resolution, a 128 kSPS data rate, and a signal to noise ratio of 106 dB in the highest-speed sampling mode. Suggested applications of this device include vibration analysis, acoustics, and pressure sensors [5].

Pipeline Architecture

The pipeline architecture is the last ADC architecture that this paper will review. This type of ADC works by using a series of comparators to determine the MSBs of the output signal, then uses a DAC and a summation block to subtract away part of the original signal. The

remainder of the signal is measured by another set of comparators, which produce the LSBs of the output. This architecture has a higher sampling rate, lower resolution, and lower signal-tonoise ratio than the other two architectures. The AD9625-2500 produced by Analog Devices, priced at \$735 (retrieved Oct 24, 2017 from the Analog Devices website), is an example of a high-end pipeline ADC. This chip is capable of 12 bits of resolution, a sampling rate of 2.5 gigasamples per second, and a signal to noise ratio of 57 dB at an 1800 MHz input frequency. Suggested applications of this device include spectrum analyzers, military communications, and digital oscilloscopes [6].

References

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