Flash Analog to Digital

What are analog and digital signals?

Analog and digital signals are two different forms of representing information or data. Analog signals are continuous waveform signals that can take on any value within a certain range. Analog signals are often used to represent continuous physical quantities such as sound, light, temperature, and pressure. For example, the human voice produces an analog signal in the form of sound waves.

Digital signals, on the other hand, are made up of binary values that can only take on two values: 0 or 1. Digital signals are used to represent discrete or quantized information, and they are often used in computer systems and digital circuits. Digital signals are easier to process, transmit, and store than analog signals, because the information in digital signals can be easily represented as a series of bits.

The easiest way to show the difference is through a visual. Figure 1 shows a great example of what analog and digital signals look like.

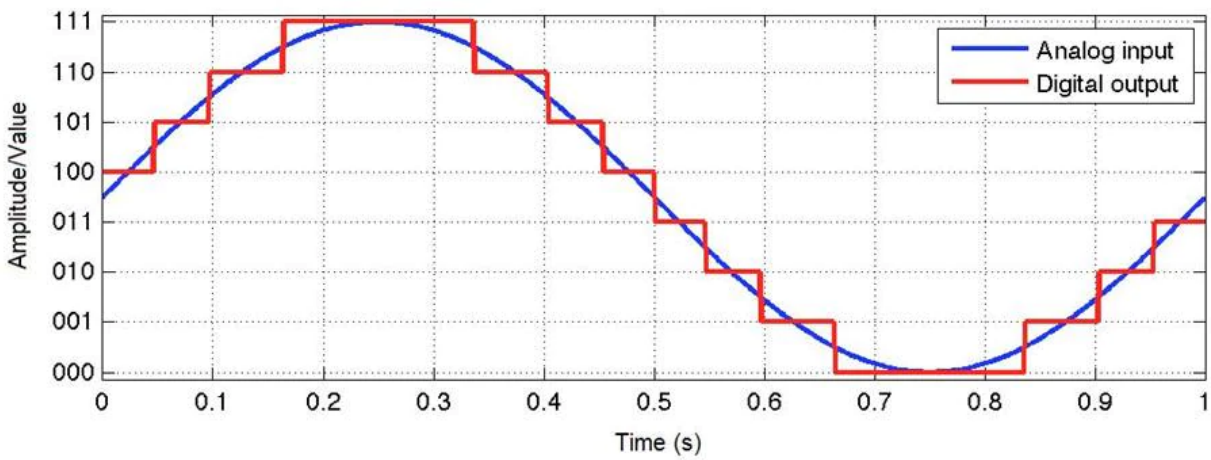

Figure 1. Analog and Digital signals comparison

To use digital signals in applications that require analog signals, the analog signals must be converted into digital signals through a process called analog-to-digital conversion (ADC). The ADC samples the analog signal at regular intervals, quantizes the signal into a set of discrete levels, and then encodes the quantized signal into a digital representation in the form of a binary number.

How does ADCs work?

Analog-to-digital converters (ADCs) work by converting analog signals into digital signals. The process involves several steps:
Sampling: The ADC samples the analog signal at regular intervals and records the amplitude of the signal at each instance as a digital value.

Quantization: The ADC compares each sample to a set of quantization levels and rounds each sample to the nearest quantization level. This results in a set of discrete digital values that represent the analog signal.

Encoding: The ADC converts the quantized values into a binary number that represents the amplitude of the signal. This binary number is a digital representation of the original analog signal.

The quality of the digital signal produced by the ADC depends on several parameters, including the sampling rate, resolution, and accuracy of the ADC. The sampling rate determines the number of times the analog signal is sampled per second, while the resolution determines the number of bits used to represent the digital signal. Accuracy refers to the ability of the ADC to produce a digital representation of the analog signal that is an accurate reflection of the original signal.

There are several types of ADCs, including flash ADCs, successive approximation ADCs, and delta-sigma ADCs, among others. Each type of ADC has its own advantages and disadvantages, and the choice of ADC will depend on the specific requirements of the application.

What is a FLASH ADC and how does it work?

A flash ADC (flash analog-to-digital converter) is a type of ADC that uses a comparator array to perform analog-to-digital conversion. The architecture of a flash ADC is made by cascading high-speed comparators. A typical flash ADC block diagram is shown in Figure 1. For an N-bit converter, the circuit uses 2N-1 comparators. The reference voltage for the comparators is provided by a resistive-divider network with 2N resistors. The reference voltage for each comparator is one least significant bit (LSB) greater than the reference voltage for the comparator immediately above it. When the analog input voltage is higher than the reference voltage applied to it, the comparator produces a 1. If the analog input is lower, the comparator output is 0. For example, if the analog input is between VX4 and VX5, comparators X1 to X4 will produce 1s and the remaining comparators will produce 0s. The code changes from 1s to 0s when the input signal becomes smaller than the respective comparator reference voltage levels.

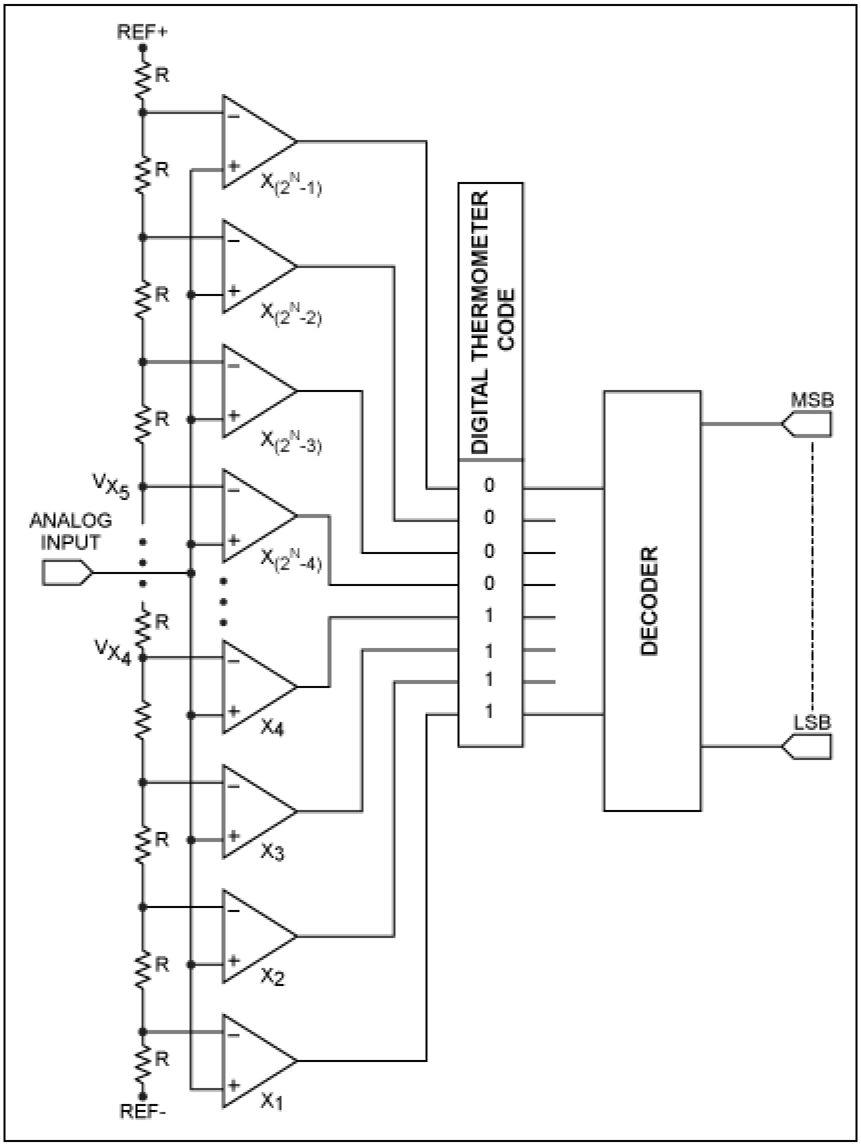

Figure 2. Flash ADC architecture. If the analog input is between V_{X4} and V_{X5}, comparators X_1 through X_4 produce 1s and the remaining comparators produce 0s.

The resolution of the flash ADC is determined by the number of comparators used in the comparator array. The resolution of the flash ADC is directly proportional to the number of comparators used in the comparator array. For example, if the ADC has 8 comparators, the output will be a 3-bit code. If the ADC has 16 comparators, the output will be a 4-bit code, and so on.

What are some architectural tradeoffs?

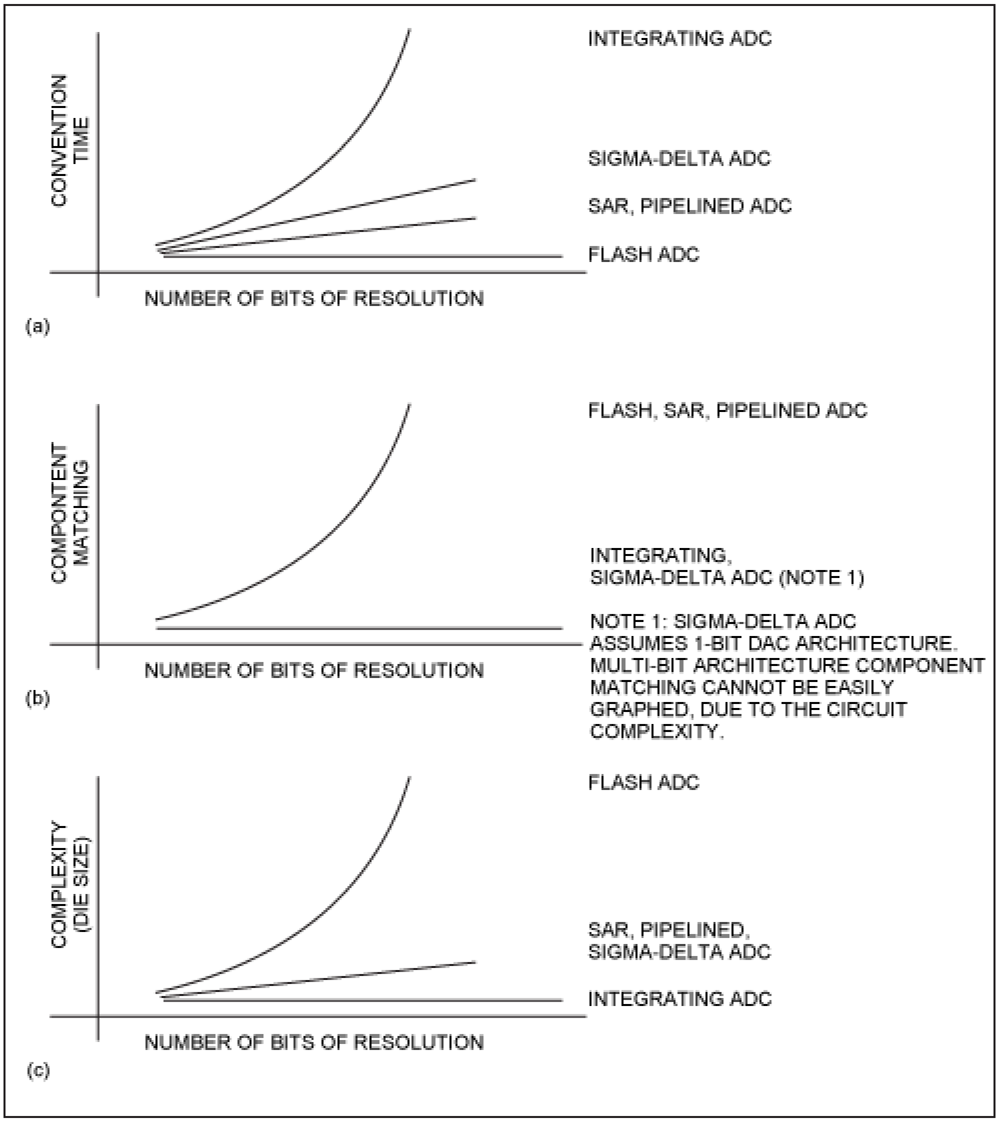

Figure 3. Architectural trade-offs.

From the figure 3, The conversion time of a flash converter remains relatively unchanged even when the resolution is increased, while the conversion time for SAR or pipelined converters increases proportionally with an increase in resolution. For integrating ADCs, the conversion time doubles with each additional bit of resolution.

The level of component matching in the circuit affects the resolution of a flash ADC, which is typically limited to around 8 bits due to matching requirements. However, calibration and trimming can be used to improve matching. The component matching requirements double with each increase in bit resolution, which also applies to SAR, pipelined, and integrating converters.

In terms of die size, cost, and power consumption, the size of the ADC core circuitry and power consumption for flash converters both double with each additional bit of resolution. For SAR, pipelined, and sigma-delta ADCs, the die size increases proportionally with resolution, but the die size of an integrating converter remains largely unchanged. Additionally, an increase in die size also leads to an increase in cost.

Conclusion

There are multiple types of ADCs and among those Flash ADCs are commonly used in applications that require high-speed and high-resolution signal conversion because of its architecture and performance.