Popular Science Summary

There are continuous analog signals and discrete digital signals in our life. For example, physical quantities in nature such as sound, temperature, and voltage are usually analog signals. These signals are continuously changing and have no discrete points in time. Digital signals are discrete signals whose amplitude can only take on specific discrete values. The most common digital signals are binary signals that can only take on the values 0 and 1. For example, the information processed within a computer is a digital signal, and all data is stored and processed in binary form.

An analog-to-digital converter (ADC) is a device that converts an analog signal to a digital signal. ADCs are used in a wide variety of applications, including but not limited to:

Audio and video equipment: Analog signals captured by microphones, video cameras, and other devices are converted to digital signals by ADCs for digital audio and video processing and storage.

Radar: Radar systems receive analog signals from the target through the antenna, and the ADC is responsible for converting these analog signals into digital form. This digitization allows the signal to be processed by digital systems, such as computers, digital signal processors, etc.

And the role of the comparator is to determine whether something is big or small. In an ADC, the job of the comparator is to compare the input analog signal with a reference voltage. If the input signal is larger than the reference voltage, the comparator outputs a high level, and if the input signal is smaller than the reference voltage, the comparator outputs a low level. This output is what is used to help the ADC determine the size of the input signal and then convert it to digital form.

Comparators have many key properties that need to be investigated and continually improved, such as speed and noise. Speed refers to how fast the comparator can complete a comparison operation. In some applications, especially in high-speed radar or communication systems, signals change very quickly, so the comparator needs to be able to react at a very high speed

or it will miss an important part of the signal. So the speed performance of the comparator is studied to ensure that it can perform the comparison operation in a very short time. Noise refers to random fluctuations in the output of the comparator that introduce uncertainty and affect the accuracy of the ADC. For instance, if the noise in the comparator output is too large, it will make the input signal not stable enough, leading to errors in the conversion results. Therefore, the study of the noise performance of the comparator is to ensure that its output is as accurate as possible and is not disturbed by noise.

In this thesis, we investigated several different structures of comparators to improve their performance for use in high-speed ADCs. During the investigation, we encountered some challenges such as trade-off between speed and noise, difficulty in establishing the correct test-bench circuit. Eventually, we successfully designed four different comparators that meet the requirements of the system ADC and compared their performance in a variety of ways.