Real Time Systems Design

Lecture (8): Digital To Analog Convertors

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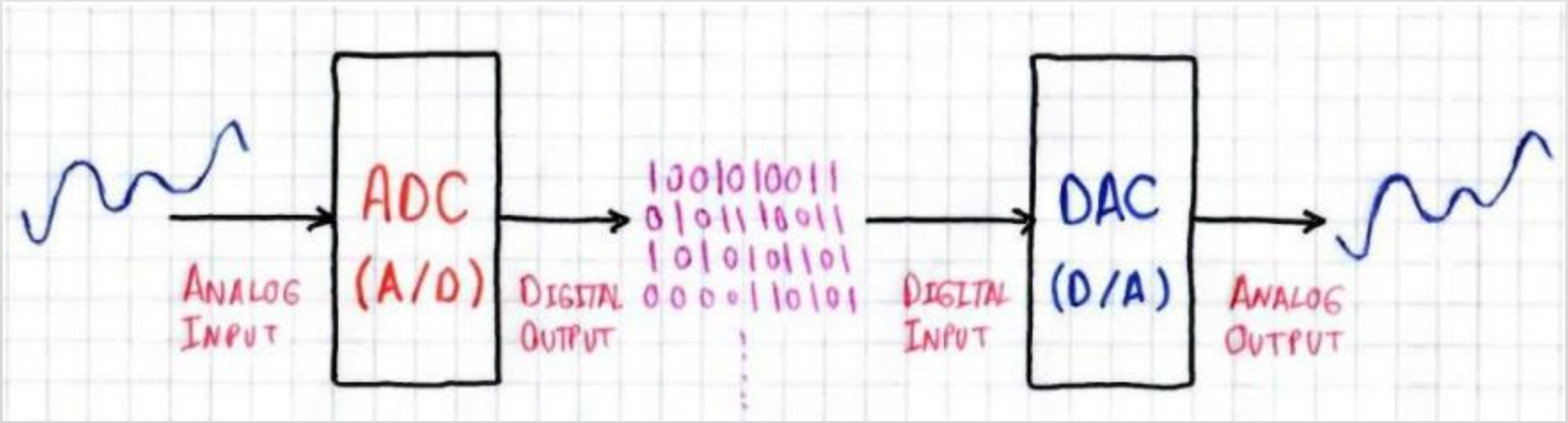
Definition of Digital to Analog Convertor

In Electronics, a digital-to-analog converter (DAC or D/A) is an electronic circuit that converts digital data (0's & 1's) to an analog signal. Functionally, it's the inverse of the ADC (analog-to-digital converter). And A DAC is remarkably cheaper than ADC by orders of magnitude.



DAC Basics

DACs are commonly used for analog waveform generation applications such as:

1 - audio/music players,

2- video players,

3- TVs,

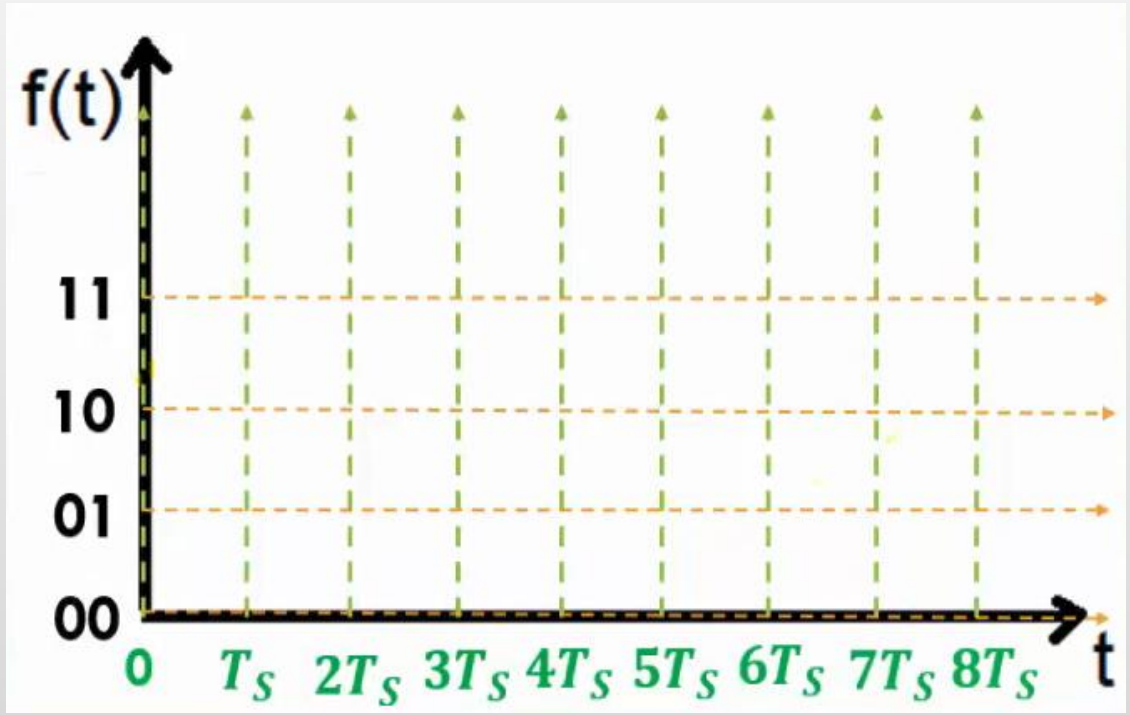
4- various other electronic systems.

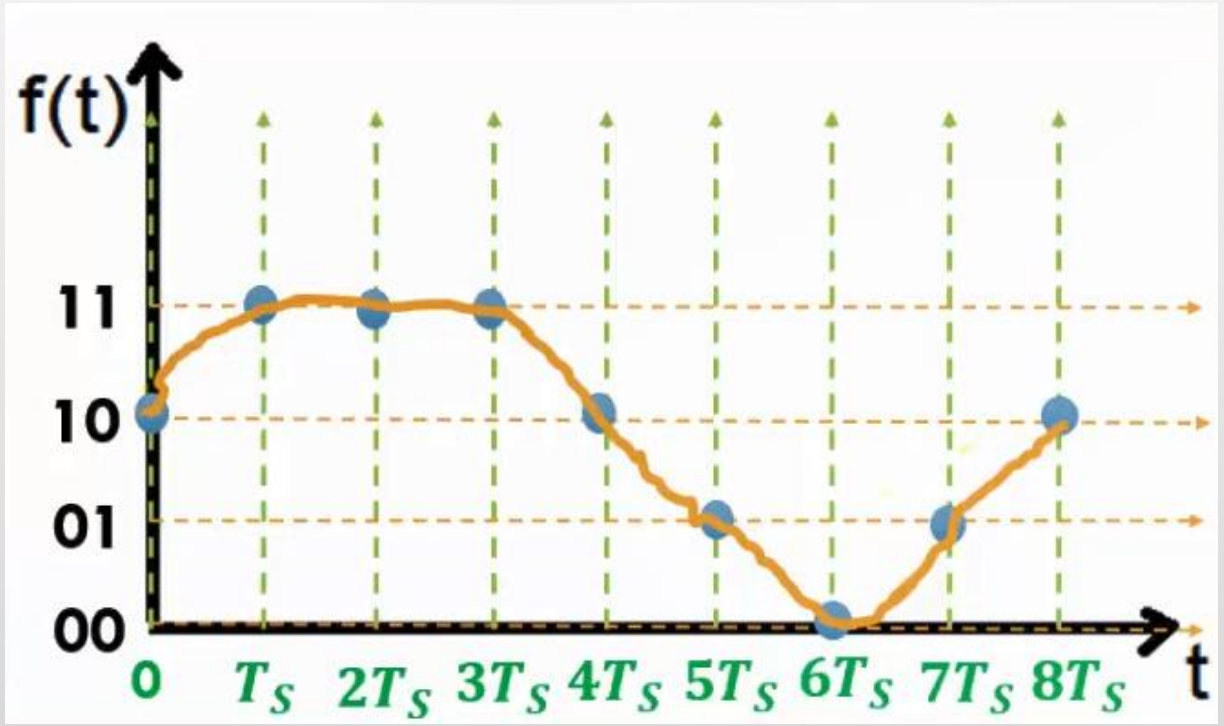
Many ADCs include a DAC as a building block of their structures in fact.

DAC Noise

As in ADC, there is quantization noise in the signal due to the fact that a DAC is converting a discrete digital data to corresponding analog voltage levels. So, there is inherent quantization noise at a rate equal to the sampling rate of the DAC.

Reconstruction





10 11 11 11 10 01 00 01 10

Nyquist-Shannon sampling theorem

As stated in Nyquist-Shannon sampling theorem, a DAC can be used to reconstruct an analog signal from digital data samples (captured by an ADC). As long as the bandwidth is less than Nyquist frequency (No violation to Nyquist sampling theorem). A reconstruction filter can be used to reduce quantization noise appearing at the analog output.

Why Do We Need DACs?

We need digital to analog converters (DACs) in different applications of digital computers. Digital computers store, manipulate, read in, and send out **Digital Data** (0's & 1's). So there should be a way to convert the digital representation back to analog signals.

Audio files are stored as digital data in the memory of a computer and in order to play it back, it should be converted back to an analog signal. Another situation in which we need DACs is analog control systems. A digital computer can monitor a process and run the instructions of a control algorithm. But in order to send out the output of the control algorithm to actuators, it should be converted to an analog voltage and here DACs come to play.

Types Of DACs

1. **Binary Weighted DAC**

The Binary-Weighted DAC contains individual electrical components for each bit of the DAC connected to a summing point. Each input in the summing has powers-of-two values with most current or voltage at the most-significant bit. These precise voltages or currents sum to the correct output value. This is one of the fastest conversion methods but suffers from poor accuracy because of the high precision required for each individual voltage or current. The most common DACs of this type are the following:

R-2R Ladder DAC, which is a binary-weighted DAC that uses a repeating cascaded structure of resistor values R and 2R. This improves the precision due to the relative ease of producing equal valued-matched resistors. It's the cheapest, yet easiest, DAC you can build on your own.

Binary Summing Amplifier DAC is basically an op-amp in summing configuration. With multiple resistors connected to one input. The junction where the resistors meet is called the summing junction or the virtual ground. The binary input goes into the resistors and the analog output is obtained on the output of the op-amp. The values of these resistors are chosen carefully to produce a binary-weighted summation for the digital inputs.

2. PWM DAC

The pulse width modulating DAC is typically a PWM generator running @ pretty high-frequency range. The analog voltage level at the output could be easily obtained by averaging the PWM signal. In technical terms, we'll filter out the high-frequency component of the PWM signal to leave only the average DC component. A simple low-pass filter could do the job. All in all, it's an efficient way to create a DAC but requires more effort to get clean output.

3. Successive Approximation (Cyclic) DAC

Cyclic DAC which successively constructs the output during each cycle. Individual bits of the digital input are processed each cycle until the entire input is accounted for.

Summary

- ✓ Definition of Digital to Analog Convertor
- ✓ DAC Basics
- ✓ DAC Noise
- ✓ Reconstruction
- ✓ Nyquist-Shannon sampling theorem
- ✓ Why Do We Need DACs?
- ✓ Types Of DACs