Discrete Time Signals & Systems – What & Why?

Signal Classification

Continuous

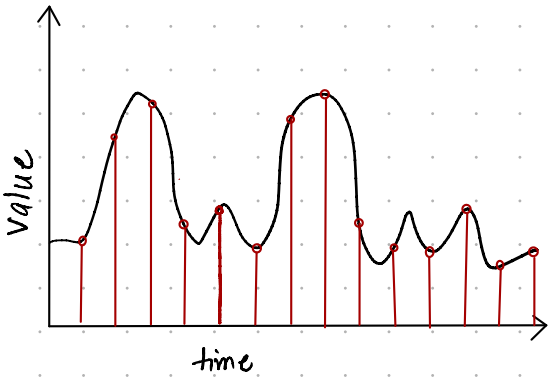
$x(t)$ → an uncountable infinite number of variable points across time.

Discrete

$x[n]$ → a countable number of variable values across time.

A discrete time signal is a sequence of values that correspond to particular instants in time.

n → count of the variable values

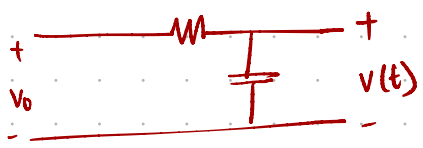


Analog (Circuits)

Analog Input → Analog System (R's, C's, Op Amps) → Analog Output Signal

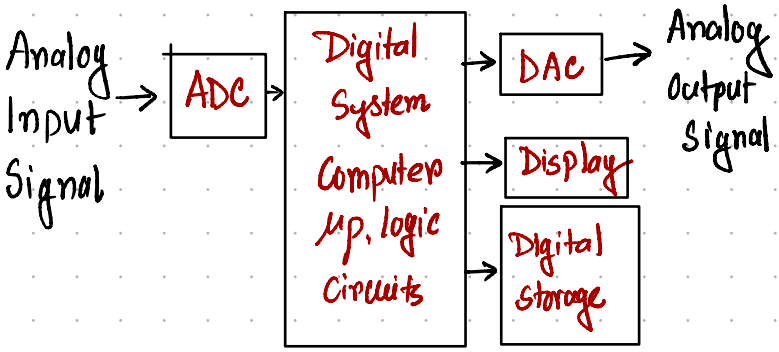
ex. RC network

$v(t) = V_0 (1 - e^{-1/RC})$



Ex. sound / speech

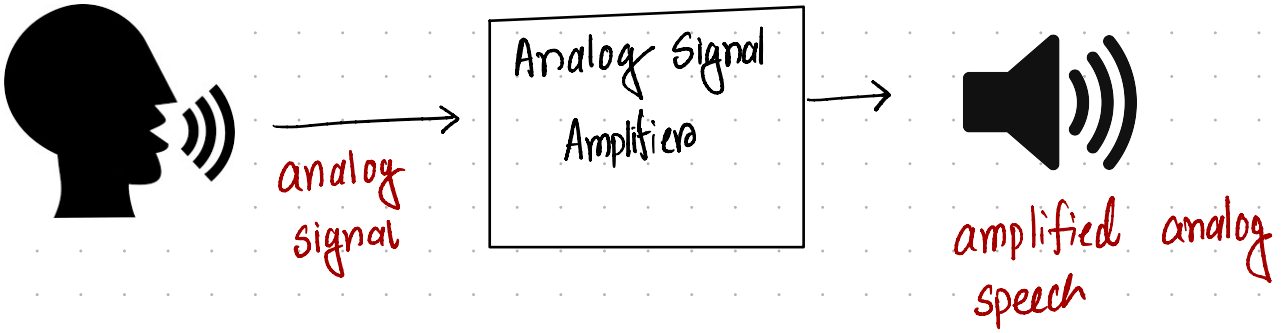
Digital (Computers)

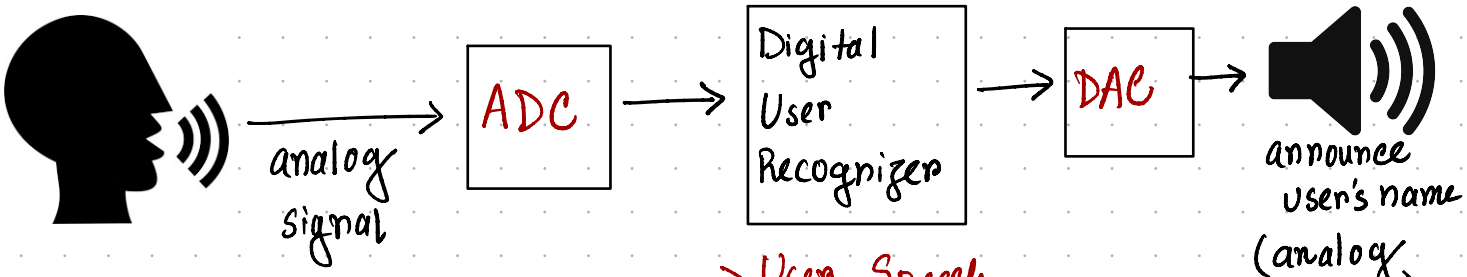


ADC → Analog to Digital Conversion

→ Digital to Analog Conversion.

Real World Scenario





→ User Speech Pattern identification.

→ Alexa, Google Home, Siri

Suggest breathing exercise.

Advantages of Digital System.

- Extremely flexible (programmable software)
- not altered by the environment.
- entirely reproducable
- simpler development on general purpose computer
- less effected by component tolerance resulting in more accuracy
- excellent for extremely complex systems.

Disadvantages of Digital System

- Slower speed (fast speed applications excluded)
- limited magnitude resolution (ultra-high-precision tasks are excluded)

Digital System / Discrete-Time System.

- A discrete time system transforms discrete-time inputs into discrete-time outputs

$$x[n] \rightarrow y[n]$$

$x(t) \rightarrow$ [ADC] $\rightarrow x[n] \rightarrow$ [DS] $\rightarrow y[n] \rightarrow$ [DAC] $\rightarrow y(t)$

ADC → Analog to Digital Conversion.

Sampling of analog signal gives us discrete signals

↓

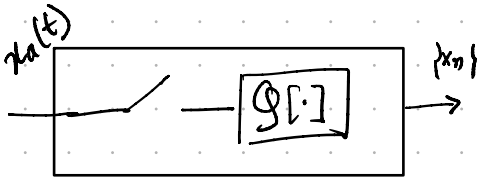
microprocessor reads finite number of voltage levels.

↓

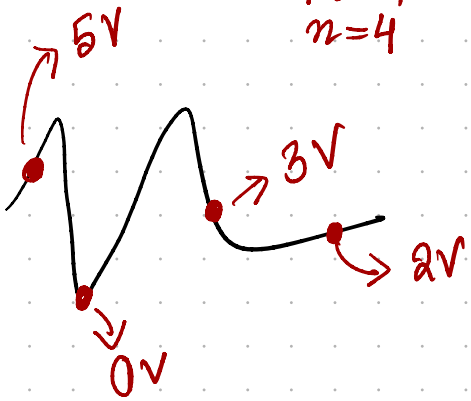
Quantization of discrete signals

↓

Resulting signal is Digital.



$\{x_n\} = Q[x_a(nT)]$



analog signal

10 bit microprocessor

[0 , 1023] → 1024 (2^{10})

5V → 1023

0V → 0

3V → 614

2V → 410

[1023, 0, 614, 410]

digital signal.

DAC → Digital to Analog Conversion

Goal: recovering an analog signal from a digital signal

- Interpolation → predic the values between two discrete values.
- Smoothing the analog filter.

MATLAB

→ Useful tool that can be used to model and analyze signals and systems.

→ This course will extensively use MATLAB throughout the term.

→ let's check how an ADC works in matlab.