Analog to Digital Conversion

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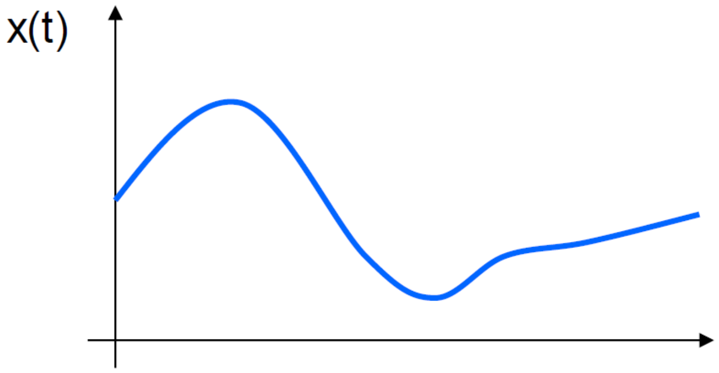
Definition & Necessity

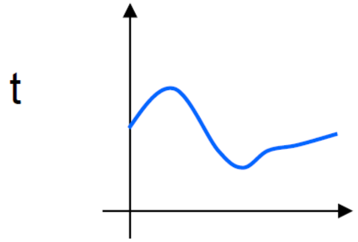
Most signals we want to process are analog

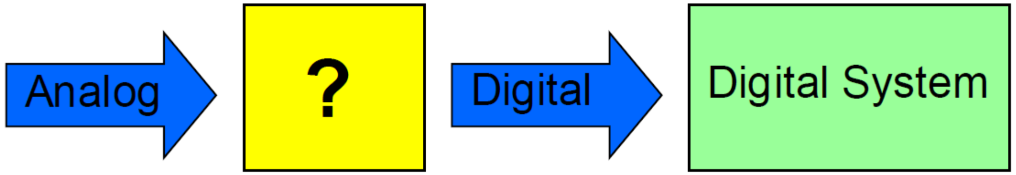
i.e.: they are continuous and can take an inifinity of values



Digital systems require discrete digital data

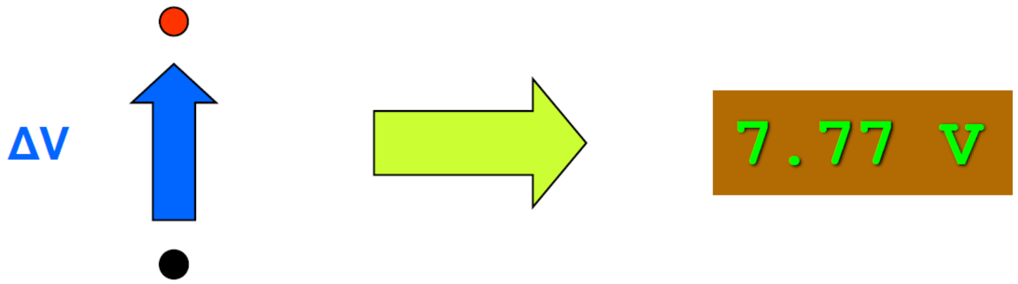
ADC converts an analog information into a digital information



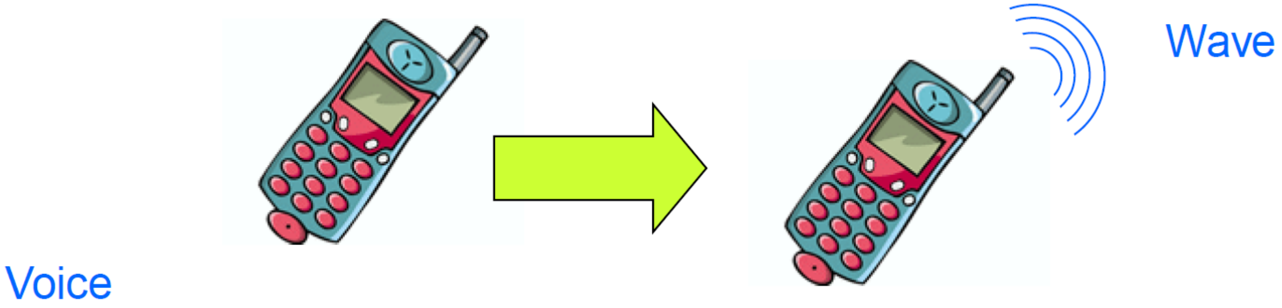


Applications

Voltmeter



- **Cell phone (microphone)**



Analog to Digital Conversion Process

3 steps:

Sampling

Quantification

Coding

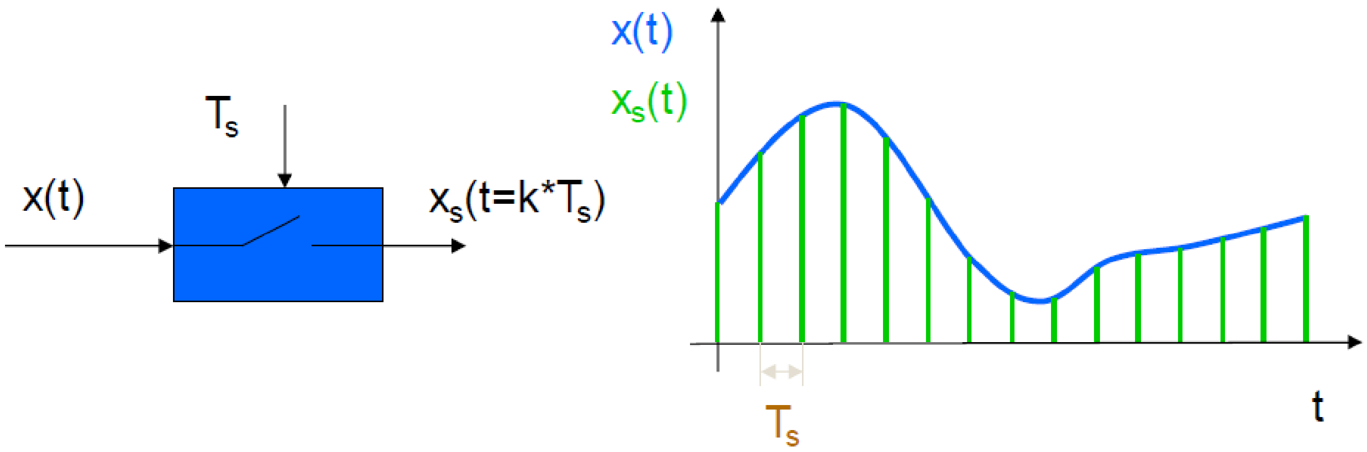
These operations are all performed in a same element:
the A to D Converter

Conversion Process: Sampling

Digital system works with discrete states

The signal is only defined at determined times

The sampling times are proportional to the sampling period (**T_s**)



Conversion Process: Quantification

The signal can only take determined values

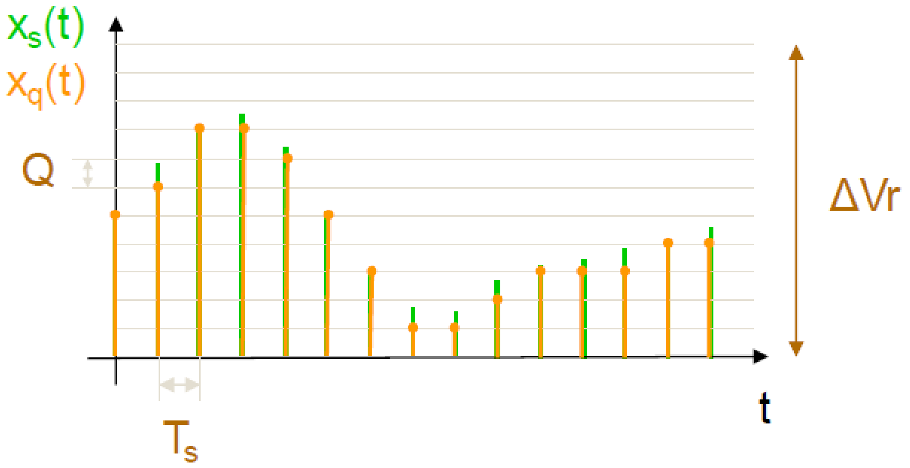
Belonging to a range of conversion (ΔV_r)

Based on number of bit combinations that the converter can output

Number of possible states:

$N=2^n$ where n is number of bits

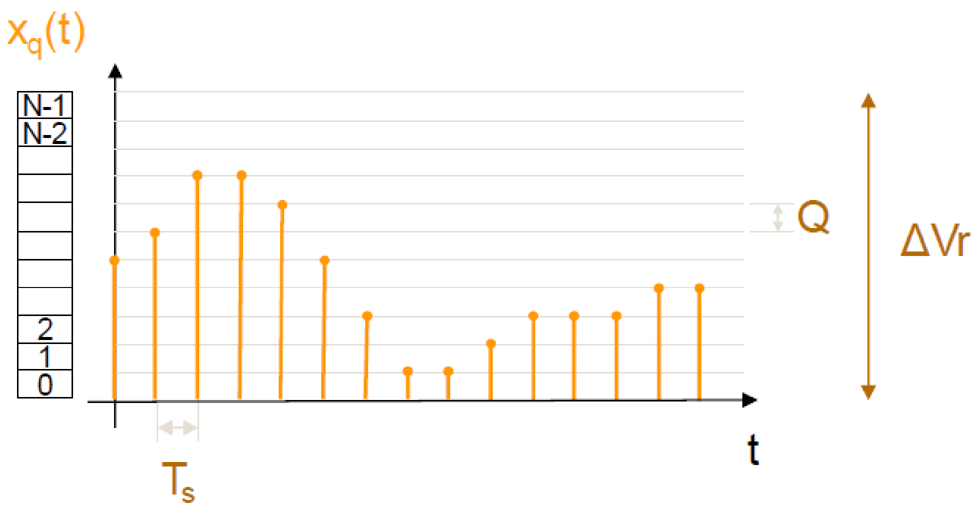
Resolution: $Q= \Delta V_r/N$



Conversion Process: Coding

Assigning a unique digital word to each sample

Matching the digital word to the input signal



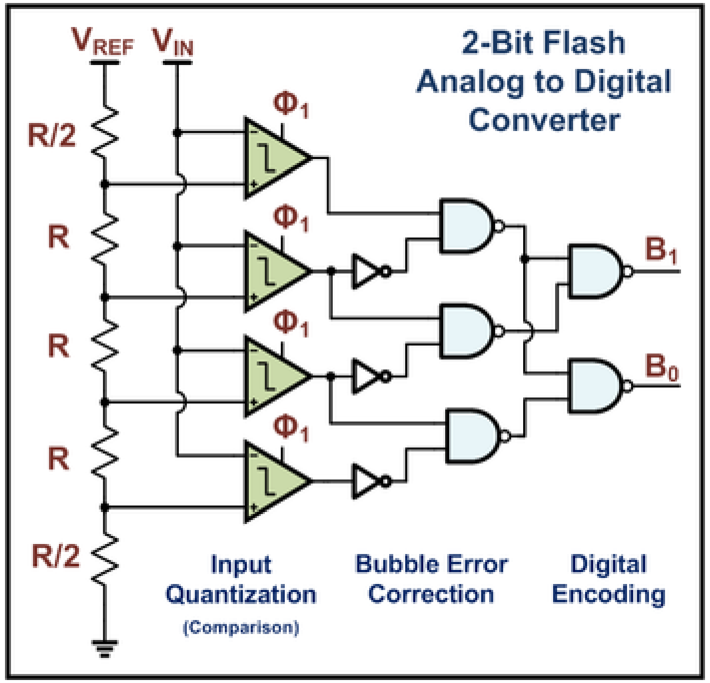
Types of ADC

- Flash ADC
- Sigma-delta ADC
- Successive approximation converter

Flash ADC

https://www.analog.com/en/technical-articles/understanding-flash-adcs.html

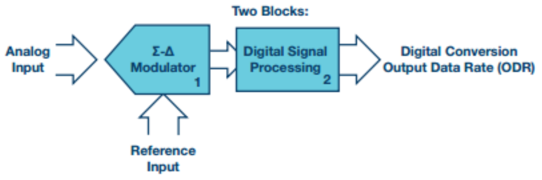
- Uses a linear voltage ladder with a comparator at each "rung" of the ladder to compare the input voltage to successive reference voltages.
- The output of these comparators is generally fed into a digital encoder, which converts the inputs into a binary value



Advantages	Disadvantages
Very fast	Needs many parts (255 comparators for 8-bit ADC)
	Lower resolution
	Expensive
	Large power consumption

Sigma-Delta ADC

- Typically there are two parts:
  - the Σ- modulator
  - digital signal processing block, usually a digital filter.

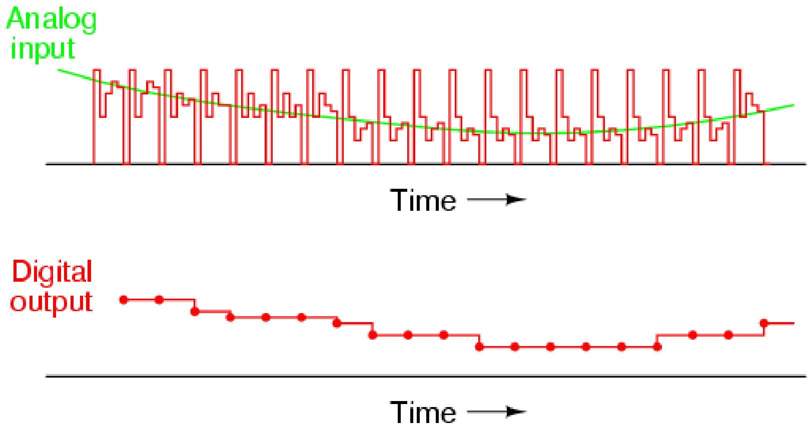


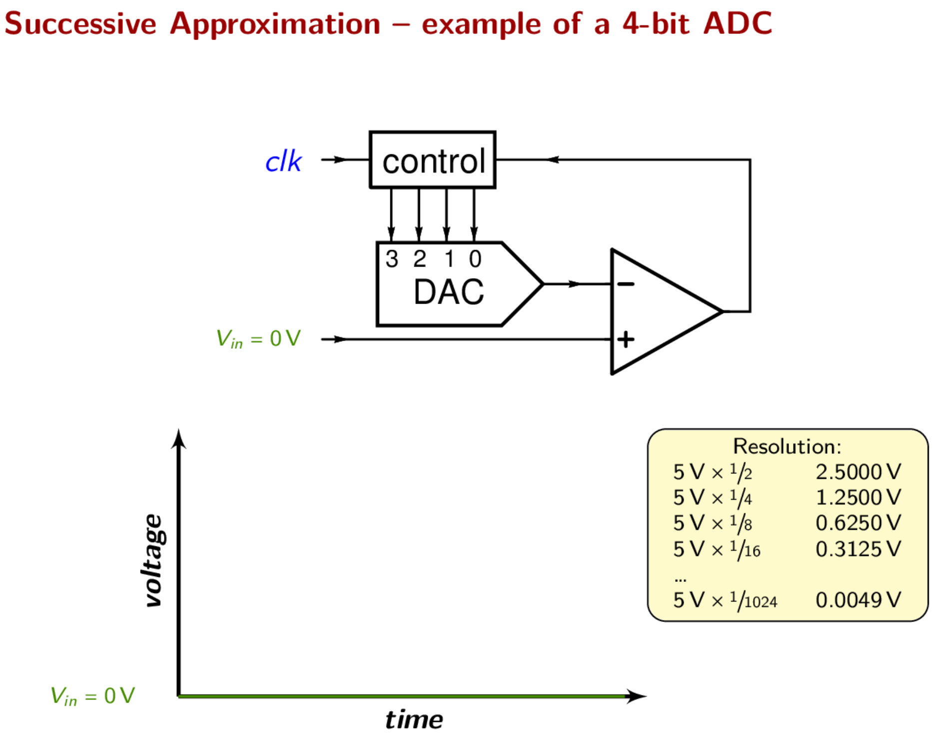
- More info here: https://www.analog.com/en/design-center/interactive-design-tools/sigma-delta-adc-tutorial.html

Advantages	Disadvantages
High resolution No precision external components needed	Slow due to oversampling

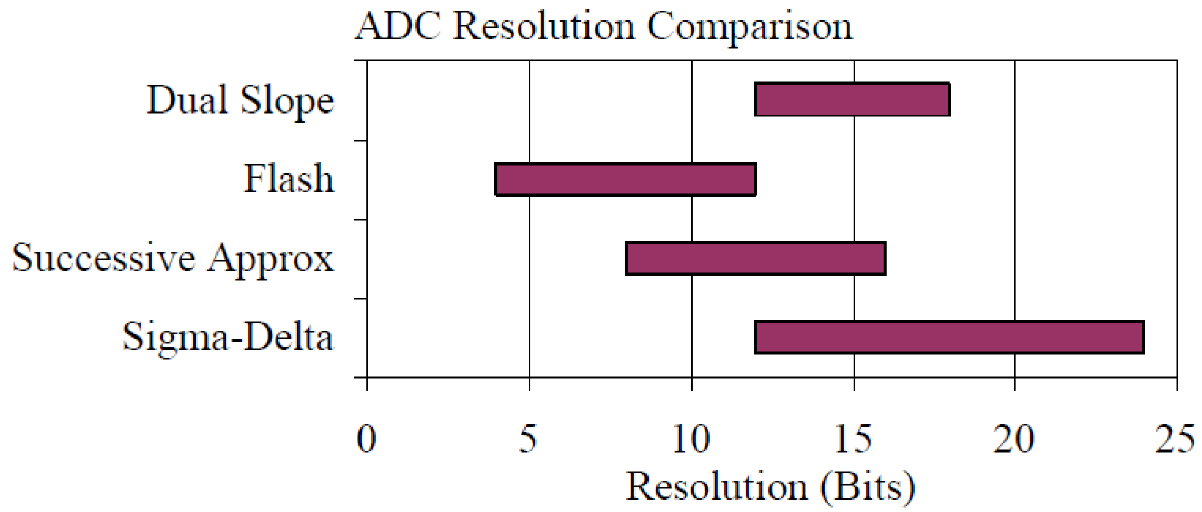
Successive Approximation ADC

- Sets most significant bit (e.g. 0b1000)
- Converts to analog using DAC
- Compares guess to input
- Sets bit
- Moves to next bit
- Operates by successively dividing the voltage range by half.





Comparison of ADC Types



Type	Speed (relative)	Cost (relative)
Dual Slope	Slow	Med
Flash	Very Fast	High
Successive Appox	Medium – Fast	Low
Sigma-Delta	Slow	Low