A/D conversion

analog signals = continuous, level of signal (amplitude) can be increased/decreased → costly to store

digital signals = discrete, one of two possible state: 1/0, on/off → insensetive to noise

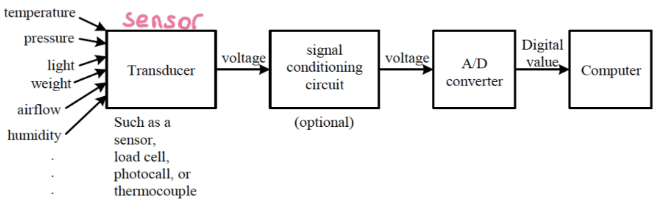
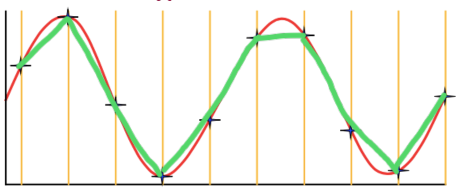


Figure 12.1 The A/D conversion process

transducer = converts physical quantities into an electrical signal (voltage), or vice versa. they sense the world.
→ sensor (ADC)
→ actuator (DAC)

analog to digital conversion (ADC) = sampling equally spaced points in time



- sampling rate is important → would be
- aliasing = if digitized version is significantly different from the original
  → has lower frequency than original
  (can be nonlinear)

→ increase the number of samples: → or

sampling theory = signal must be sampled at least twice the frequency of original signal to repodvce it correctly

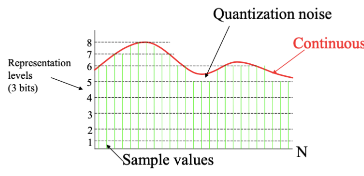
→ nyquist rate = value equal to twice the highest frequency of a given signal

digital to analog conversion = reconstruction of signal from the samples

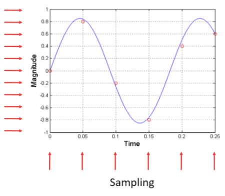
sampling rate = how often analog signal is measured → samples per second, Hz → time axis

sampling resolution = precision of numbers used for measurement, sample world length, bit depth → number of bits used to represent y-axis

quantization = approximating values into set of discrete values → cannot reconstruct the same signal



process of making y-axis discrete ← Quantization



→ making x-axis magnitude

- aliasing causes sampling high frequency signals to low frequencies, to prevent this and ADC has a low-pass anti-aliasing filter → reduces the frequency before sampling

Spatial sampling = number of samples are taken to determine the contents of a larger geographical area

full-scale range = largest voltage range which can be input into the A/D converter (max − min) − FSR

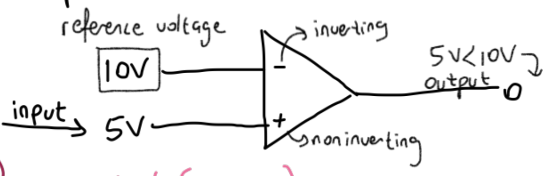
step size / least significant bit = represents the smallest change that can be resolved by the ADC − LSB

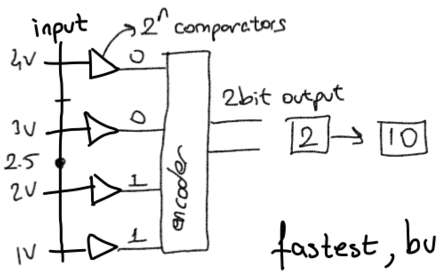
$LSB = FSR/2^n$ $\quad 5V/2^8 = 19.53\,mV$

types of A/D conversion =

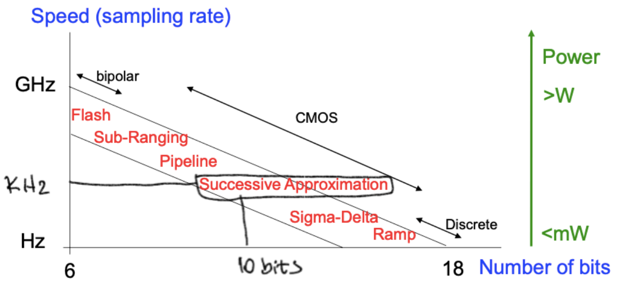
① flash (parallel) =

Comparator:





fastest, but too much hardware



② sequential (counter) =

- keep incrementing result register until DAC produces a voltage greater than V_{in} → max 2^n steps
- simple hardware but too slow

③ successive approximation =

- binary search, time ≈ # bits (independent of the input voltage) → PIC with 10-bit one

16 V = reference voltage (4 bit)
$V_{in} = 11.2\,V$

1000 $\xrightarrow[\text{keep 1}]{V_{in} > 8V}$ 1100 $\xrightarrow[\text{make it 0}]{V_{in} < 12V}$ 1010 $\xrightarrow[\text{keep 1}]{V_{in} > 10V}$ 1011 keep 1

acquisition time = while determining the corresponding digital value of an analog input, the input voltage must remain same, but it does not. Then charge a capacitor to keep same voltage for a certain amount of time. acquisition time is the time it takes to charge the capacitor.

settling time = time required for digital output to reach the corresponding value (flash < successive < sequential)

throughput rate = number of conversions per second, measured in Hz conversion time = acquisition + settling time

average error = $V_{max} / 2^{n+1}$

amplification = if max sensor output 2V, ADC unit is 5V → scale (multiply) input (gain)

A/D conversion with PIC 18F

13 possible inputs, 10-bit resolution, no built in D/A converter, 5 registers

A/D result registers → ADRESH, ADRESL

A/D control registers →
- ADCON0 = select channel for input, bit 1 → 1: start, 0: end of conversion
- ADCON1 = set up I/O pins (digital or analog), select referance voltage
- ADCON2 = select acquisition time and clock frequency

binary value of an input = between 0V and 5V
10 bits ⇒ $2^{10} = 1024$ levels

5V → 1024
3.65V → x

$\frac{1024 * 5}{3.65} = 747.52 \approx 748$