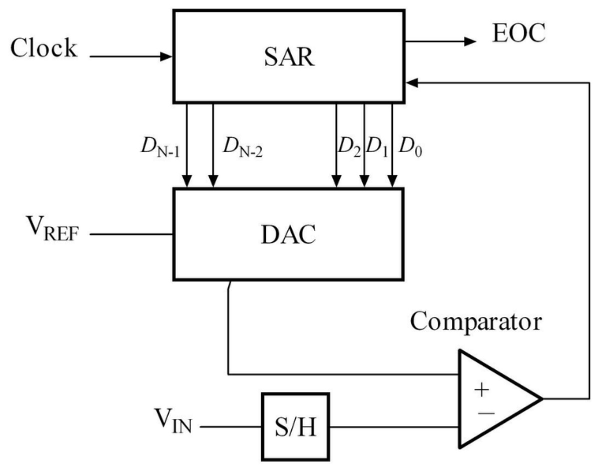
DAC/ADC Summary

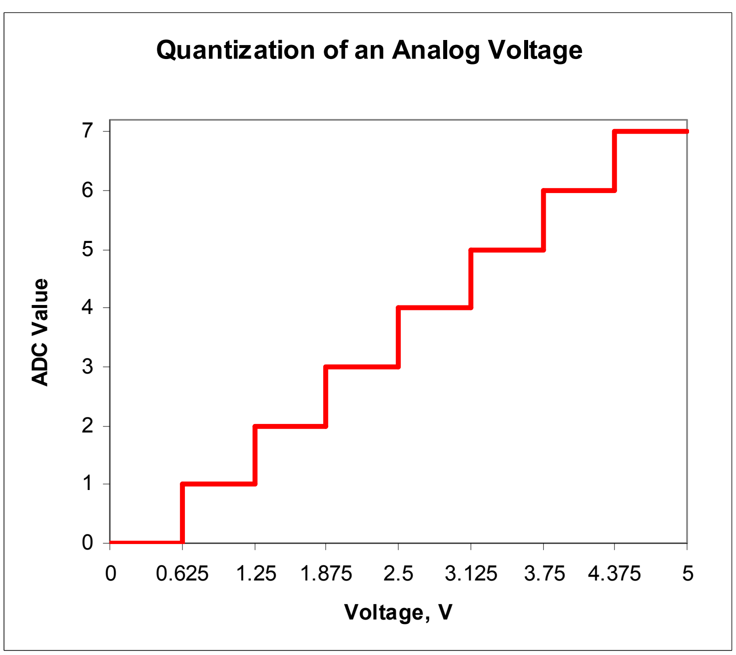
Major Points

- Digital-to-Analog Converter (DAC) usually an R-2R ladder DAC, which consists of a voltage divider network (divides a reference voltage down by 1/2 for each ‘rung’ of the ladder) and a summing amplifier. Voltage out depends on which bits are on or off.
- The resolution for a DAC or Analog-to-Digital Converter (ADC) depends on the number of bits it has: resolution = $1/2^N$, where N = number of bits. Thus a 10-bit ADC (like that on the ATmega328 has a resolution of $1/2^{10}$ => one part in 1024. If the reference voltage is 5V, the voltage resolution is about 5V/1024 = 4.9 mV. Thus, to detect a change in an unknown voltage, it will have to change by more than 4.9 mV.
- A Successive Approximation ADC uses a DAC, a comparator, and a register to convert an unknown voltage into a digital value.



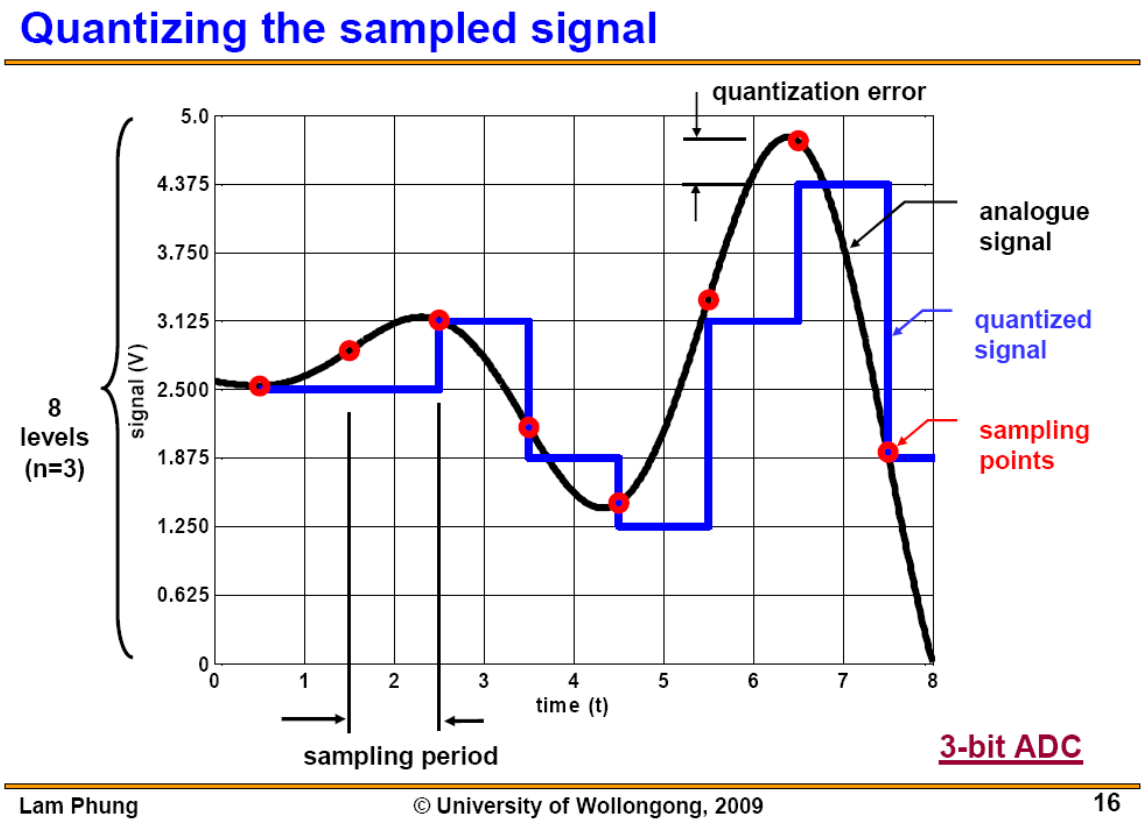
http://upload.wikimedia.org/wikipedia/en/6/61/SA_ADC_block_diagram.png

- Analog-to-Digital Conversion essentially quantizes an analog signal. Consider a 3-bit ADC with a 5V reference. DV = $V_{ref}/2^N = 5V/2^3 = 0.625$ V



$$\text{ADC value} = \frac{V_{in}}{V_{ref}} 2^N$$

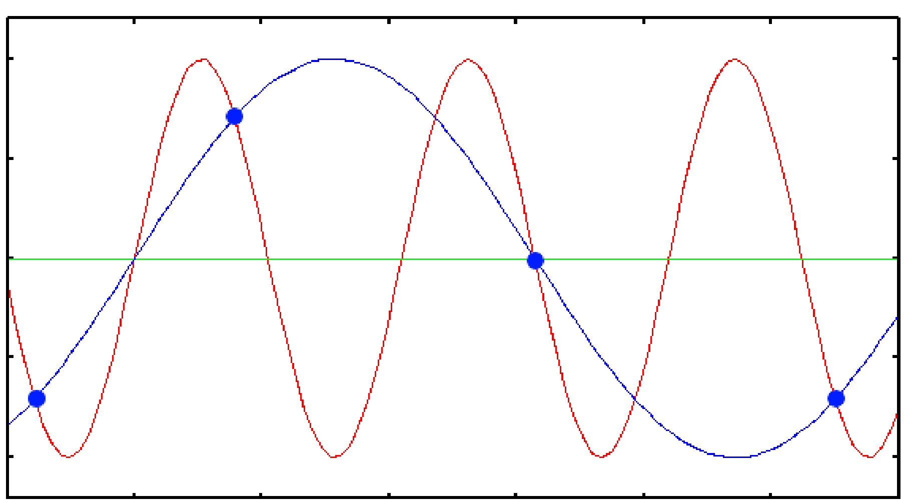
(round down)



(Source: http://www.elec.uow.edu.au/avr/ecte333/ECTE333-Lecture-11.pdf)

- Quantization error is the difference between the actual analog voltage value and the discrete voltage step value corresponding to the converted digital value. Ideally ±1/2LSB
- The Nyquist theorem establishes a minimum sampling rate so that the frequency of the sampled signal can be faithfully reconstructed from the digitized version. If possible, try to sample at least 5x-10x the Nyquist rate.

$$\text{Nyquist sampling rate} = 2\,\boldsymbol{f}_{\max}$$
$$\text{where } \boldsymbol{f}_{\max} \text{ is the maximum frequency in the signal}$$



Source:(http://support.svi.nl/wikiimg/Aliasing-plot.png)