Analog-Digital Conversion

DAC: digital-to-analog conversion
ADC: analog-to-digital

Concepts: resolution, speed

Resolution is measured in no. of bits \( N \)

\[ 2^N = 2^8 = 256 \] possible values

Example:

8-bit converter, with full-scale (FS) 0-10V analog

<table>
<thead>
<tr>
<th>Digital Level</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>000000000</td>
<td>0.000V</td>
</tr>
<tr>
<td>000000001</td>
<td>0.039V</td>
</tr>
<tr>
<td>000000010</td>
<td>0.078V</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>111111111</td>
<td>10.000V</td>
</tr>
</tbody>
</table>

given an analog voltage, the converter will choose the nearest discrete value

e.g., in example above, an actual analog voltage of 0.0423V is approximated as 0.039V.
Speed is measured in Sample Rate.

E.g., multimeter 2x10^5 samples/sec
digital scope 2x10^9...

Tradeoff: Faster conversion vs. high resolution

![Graph showing resolution (bits) vs. samples per sec on a log scale, labeled with 2004 data.]
concept: aliasing & Nyquist frequency

**Sampling Theorem**

If your input signal is periodic at freq. $f$, you need a sample rate at least as fast as the Nyquist frequency $f_{\text{Nyquist}} = 2f$, to reconstruct the signal.

Example: to record audio with a bandwidth up to 20 kHz, you must have sample rate $\geq 40$ kHz samples per sec.

Oversampling: sample rate $\gg f_{\text{Nyquist}}$

- Analog input
- Sampling lines
- What is recorded by ADC

Undersampling: sample rate $< f_{\text{Nyquist}}$

- Analog input
- Sampling lines
- What is recorded by ADC
Aliasing

An artificial oscillation due to sampling slower than Nyquist freq.

Ex: TV 30 images per second ⇒ \( f_{\text{Nyq}} = 15 \text{ Hz} \)
wheel rotating at 16 Hz

Angular rotation of wheel

What you see - a 1 Hz rotation

Google:
- Video: frame aliasing propellers
- Images: aliasing