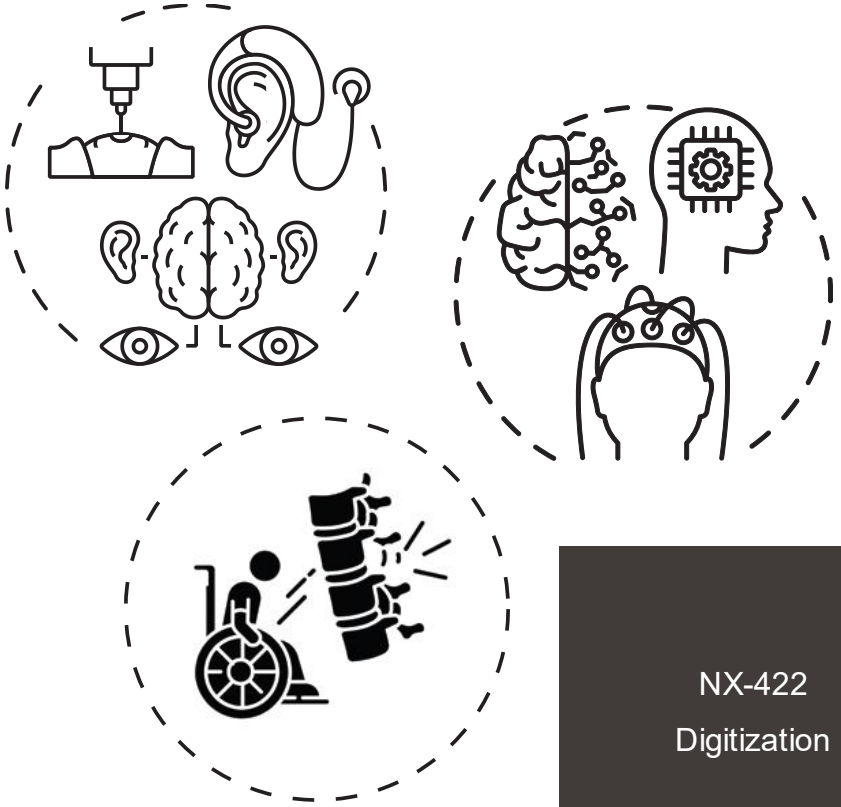


Neural Interfaces

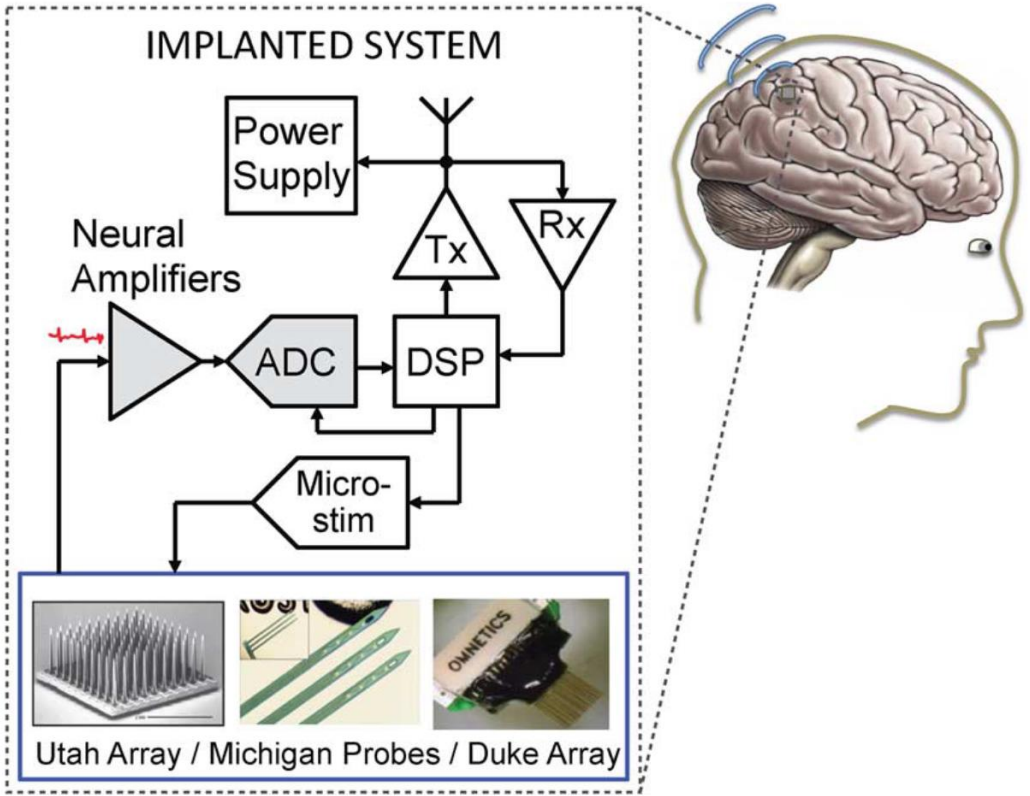
NX-422

Digitization

Mahsa Shoaran

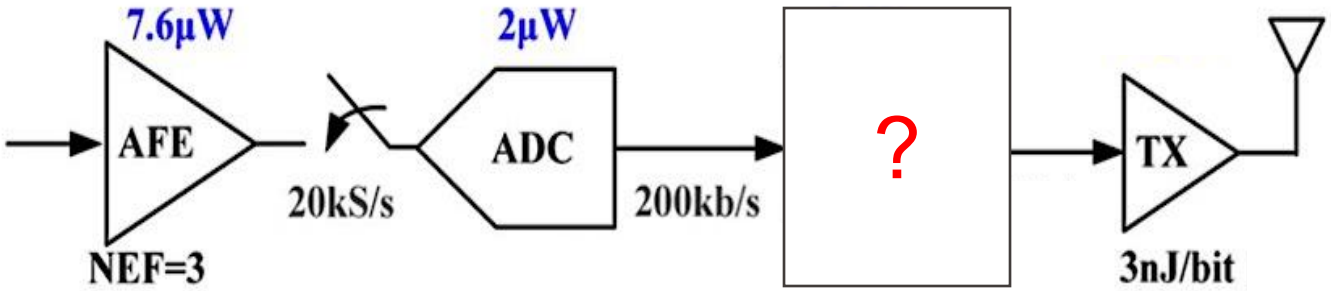
IEM and Neuro-X Institutes

Circuit Block Diagram of a Neural Interface: ADC



Neural Interface: ADC and Compression

- The typical circuit blocks used in sensors for medical monitoring and their associated energy cost and power consumption



F. Chen et al, *JSSC'12*

Neural Interface: ADC and Compression

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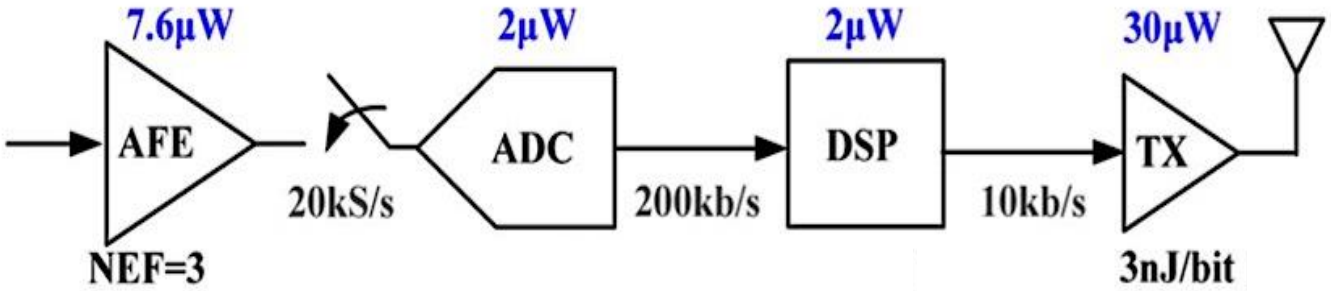
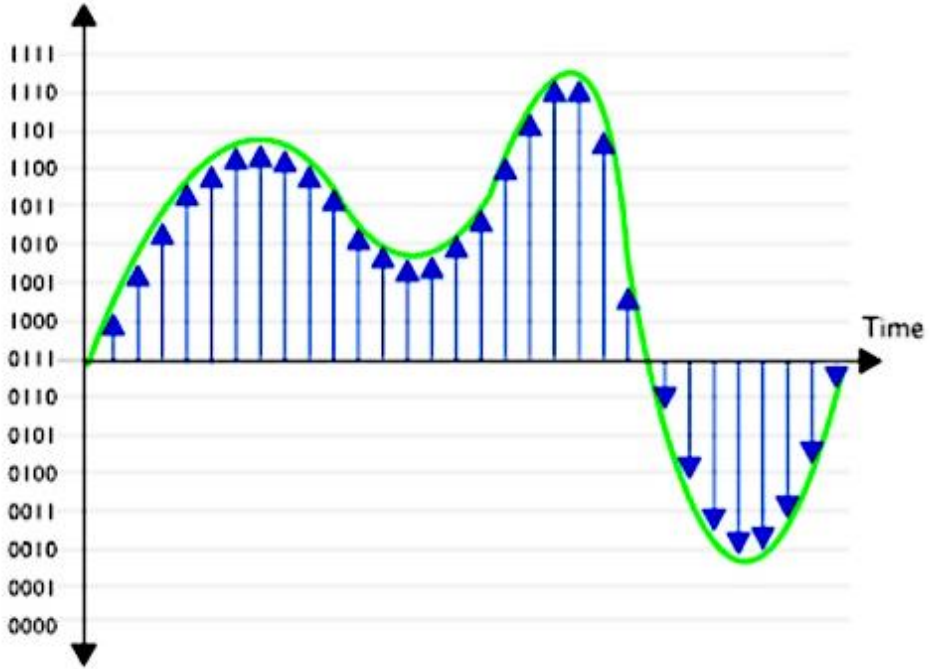


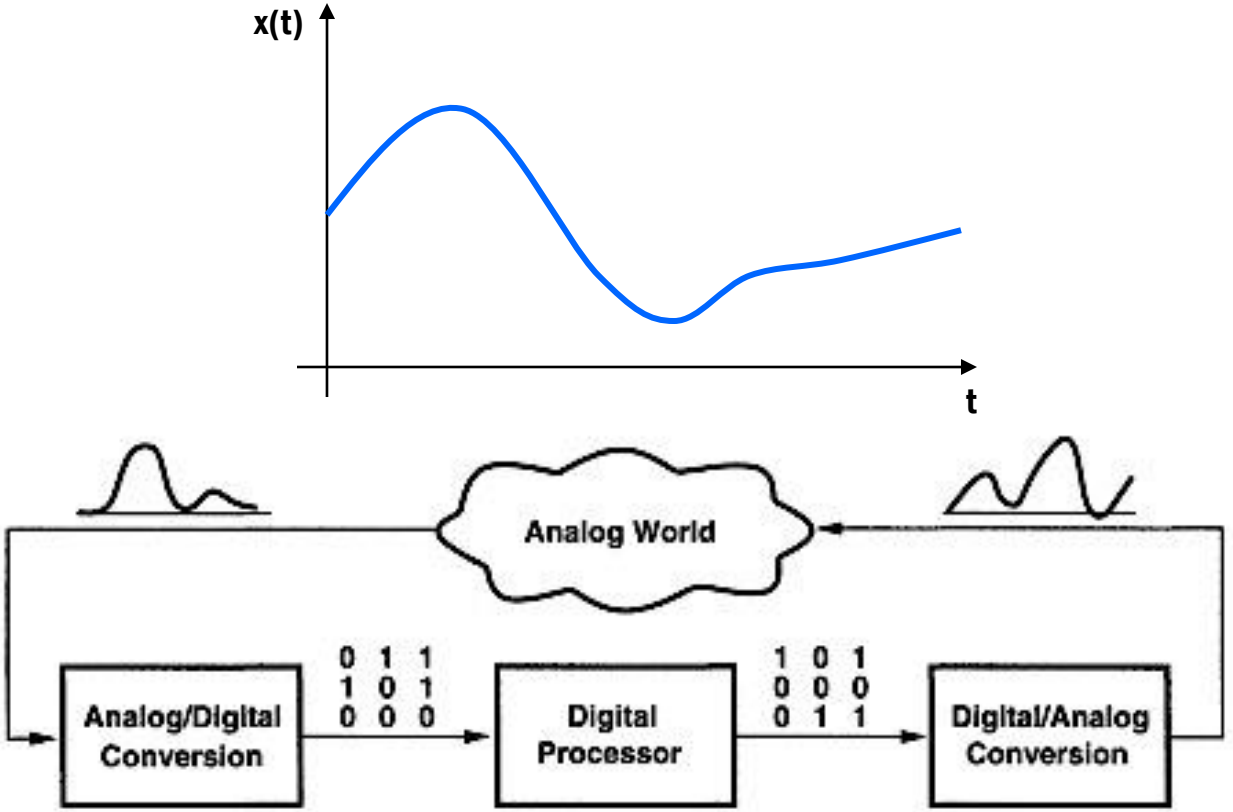
F. Chen et al, *JSSC'12*

Analog to Digital Conversion

- After amplification and filtering, signal is digitized (sampled at a fixed rate)



Analog and Digital Signals



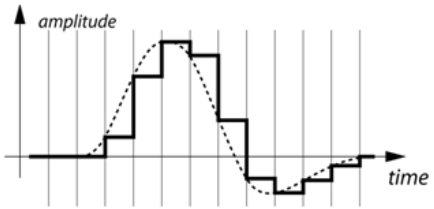
Digital Data Acquisition

Foundation: *Shannon/Nyquist sampling theorem*

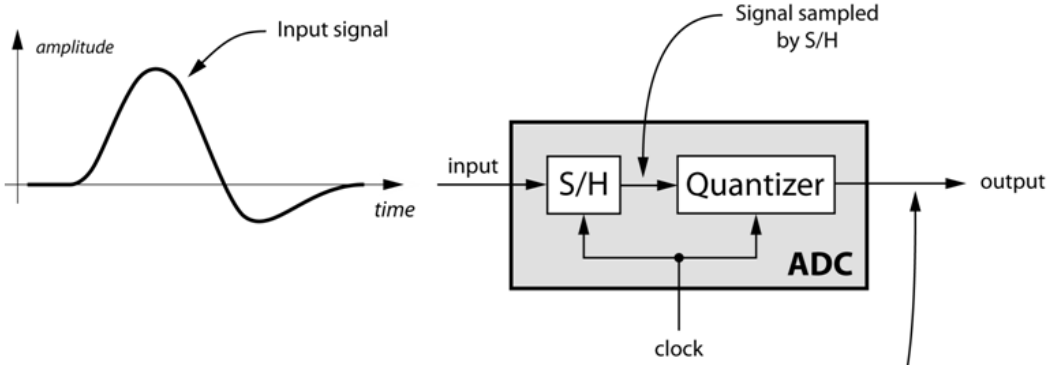
"if you sample densely enough (at the Nyquist rate), you can perfectly reconstruct the original analog data"

- A bandlimited analog signal can be perfectly reconstructed from a sequence of samples if the sampling rate **fs** exceeds $\mathbf{2f_{max}}$ samples per second, where f_{max} is the **highest frequency** in the original signal.

ADC Basics

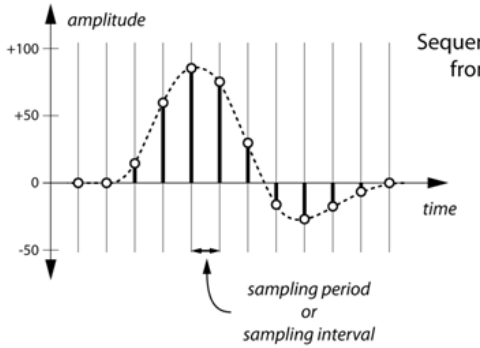


Stage 1



Sequence of numbers
from quantizer

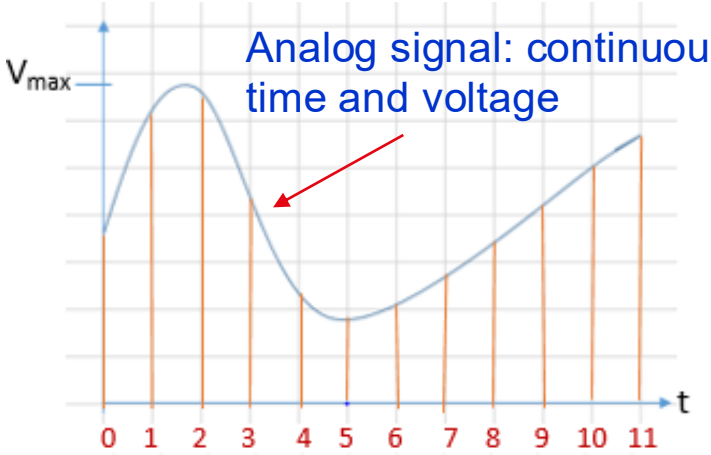
Stage 2

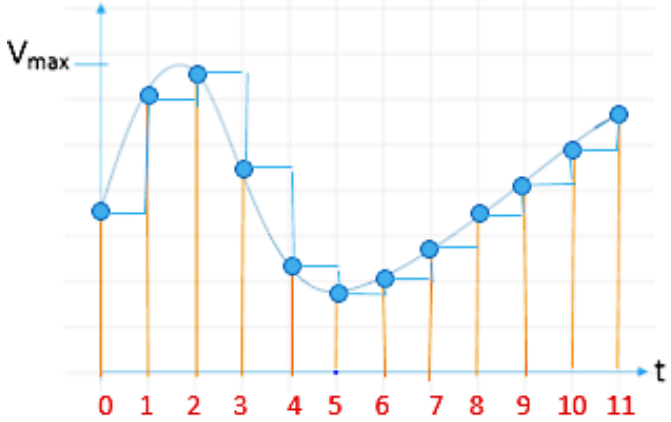


⇨ *{…, 0, 0, +15, +60, +85, +72, +28, -17, -30, -21, -8, -1, …}*

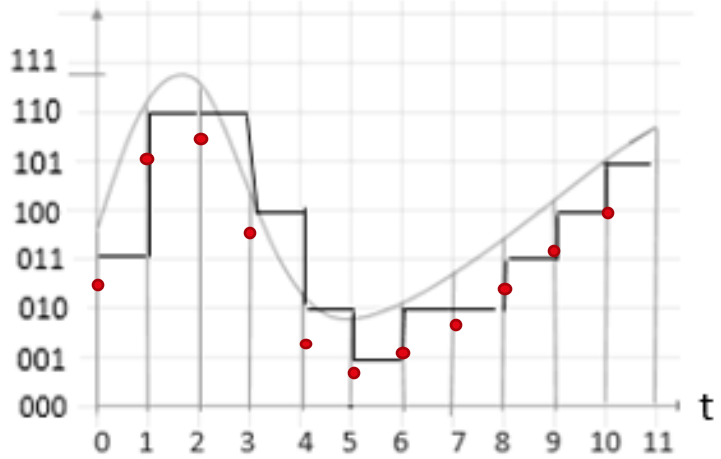
ADC Operation

Sampling and Holding



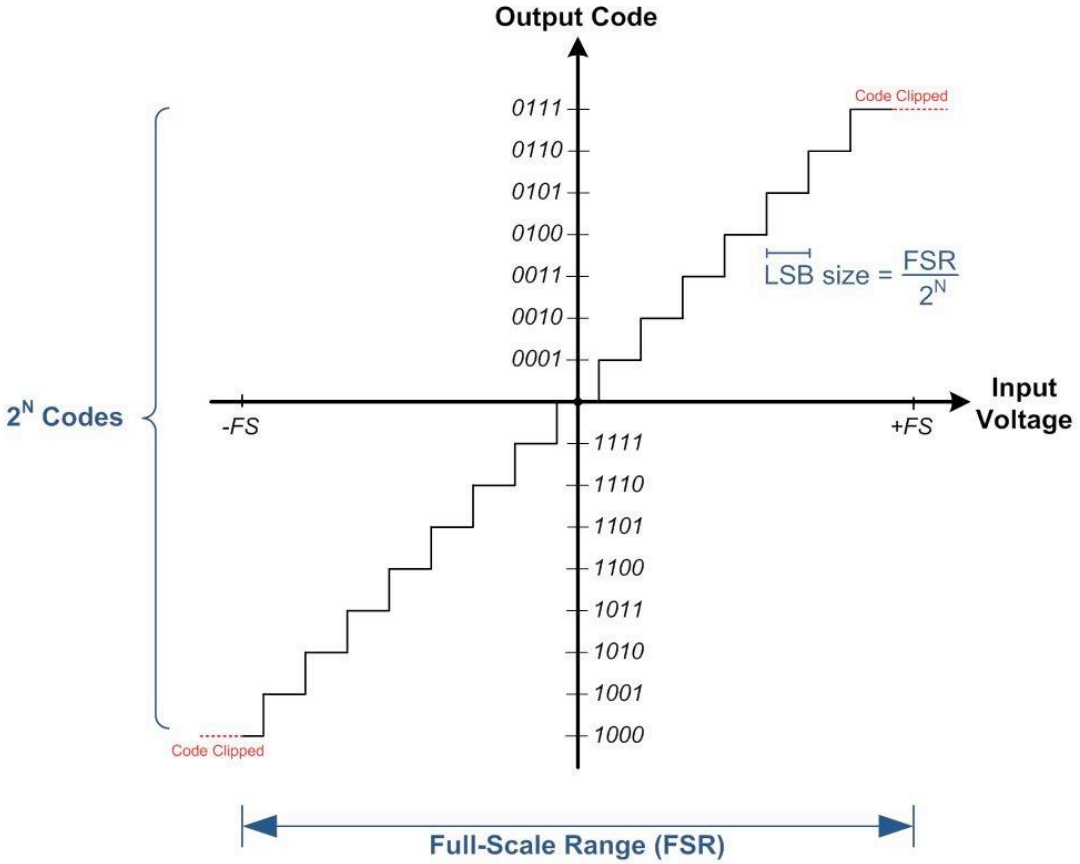


Quantization and Encoding

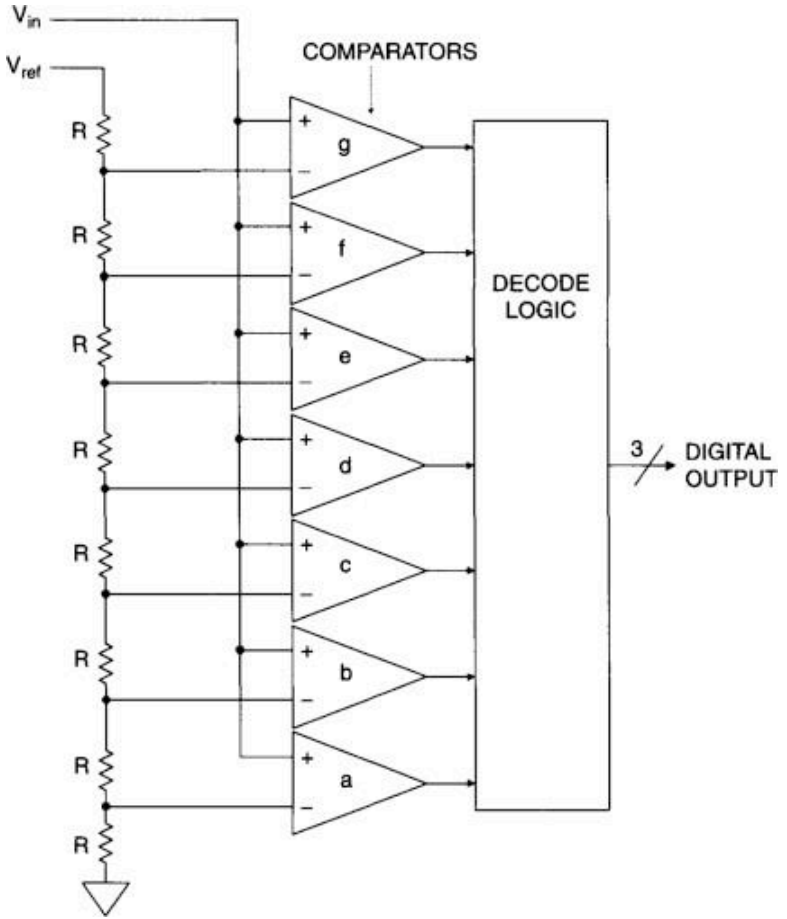


Sequence of digital codes:
011, 110, 110, 100, 010, 001, 010, 010, 011, 100, 101, …

The least significant bit (LSB)



3-bit flash (parallel) ADC



- An n-bit flash ADC uses 2^n-1 comparators, 2^n resistors and a decode logic.

- Pros: the fastest type of ADC.
- Cons: limited resolution, expensive, large power consumption

- Applications: Sampling oscilloscope and high-density disk drives

Successive-approximation-register (SAR) ADC