KNOW-HOW TO CREATE / AXIOM-IC.COM

Successive Approximation ADCs

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- Analog-to-Digital Conversion
- ADC architectures – flash, pipeline
- Successive Approximation ADC
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Axiom IC

Who we are

- Mixed-signal IC design house
- Specialized in low-power data converters and audio
- Located in Enschede
- Close contacts with University of Twente
- Founded in October 2007
- 13 Employees

ADCs

Why are they needed

ADCs

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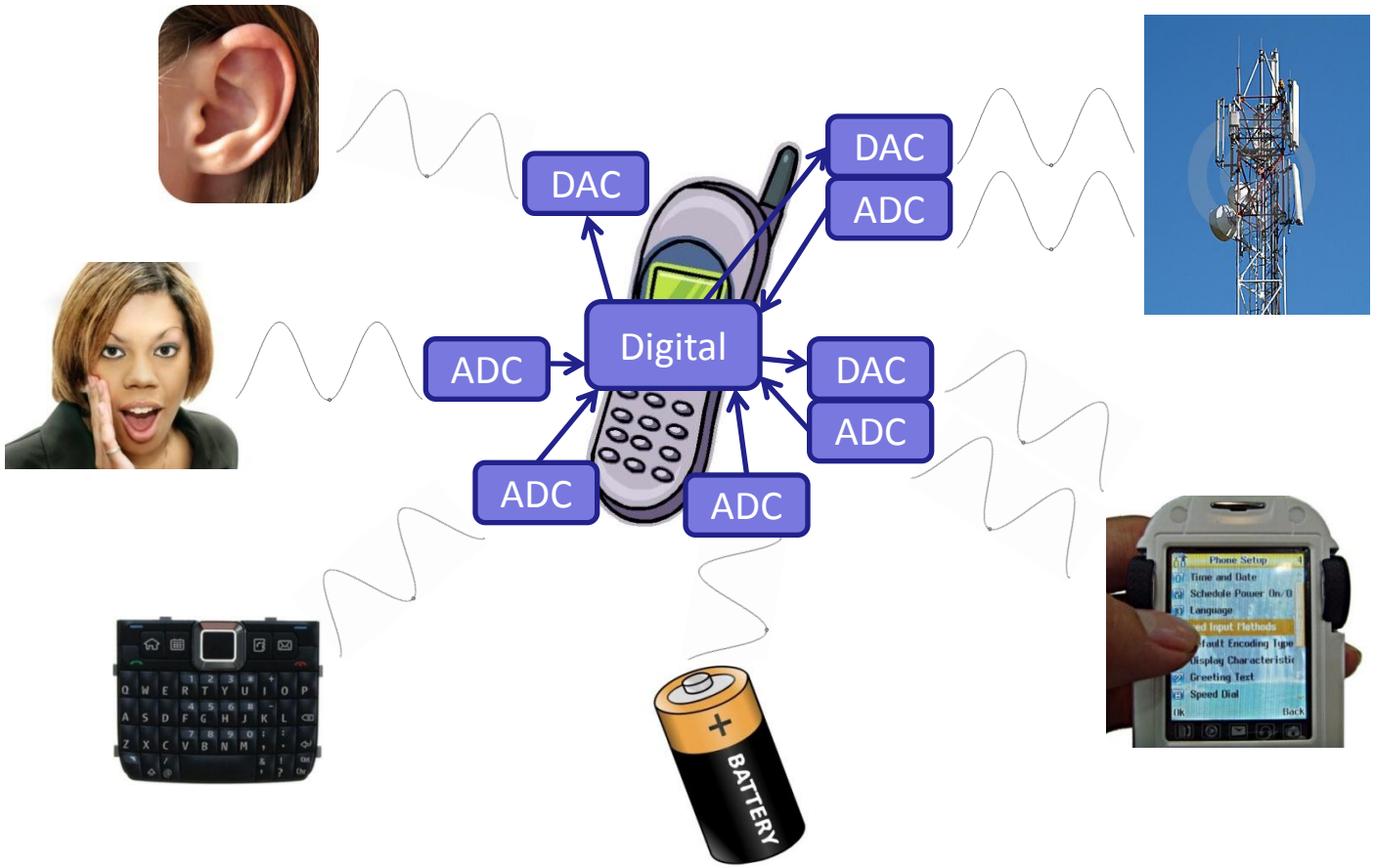
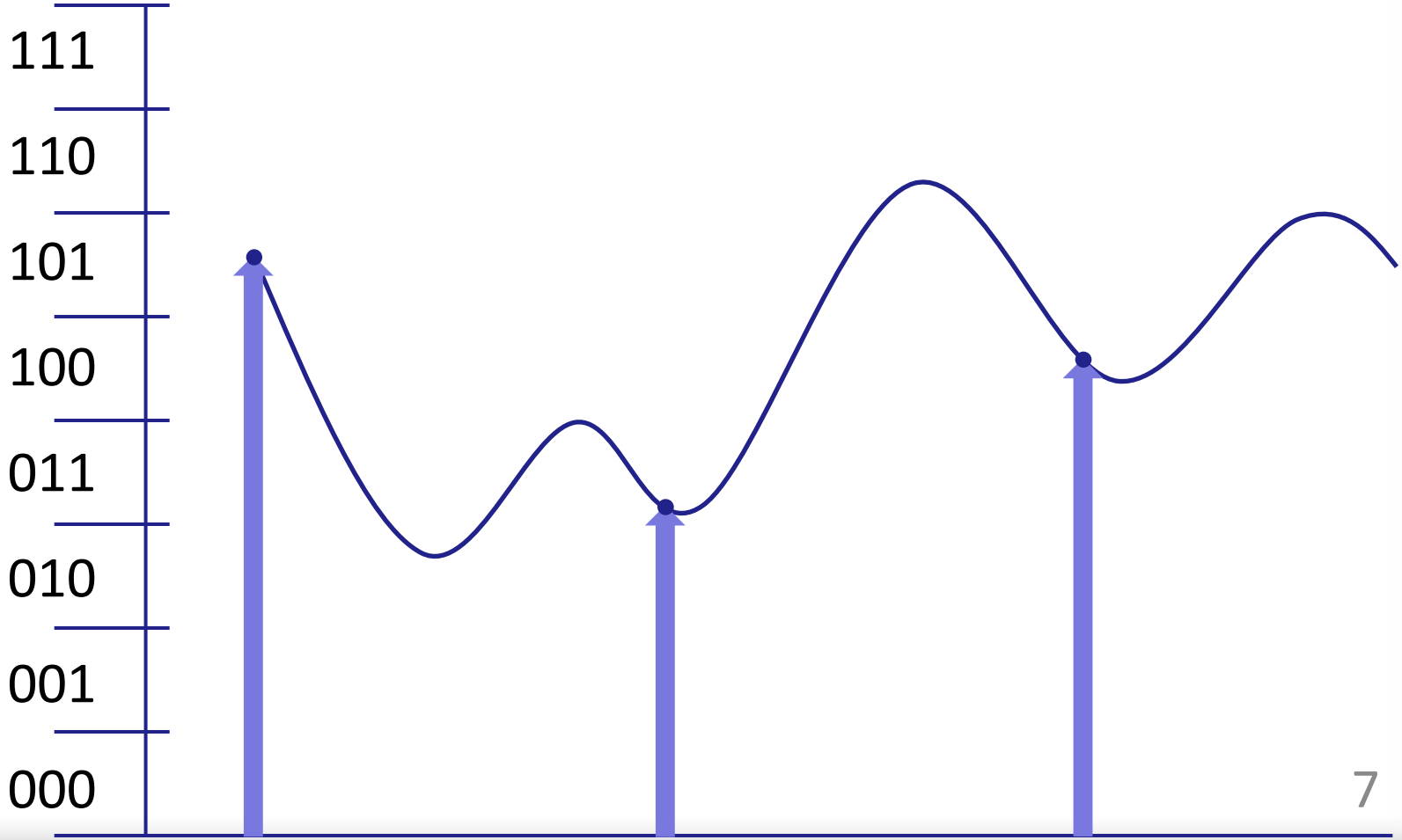
Why are they needed

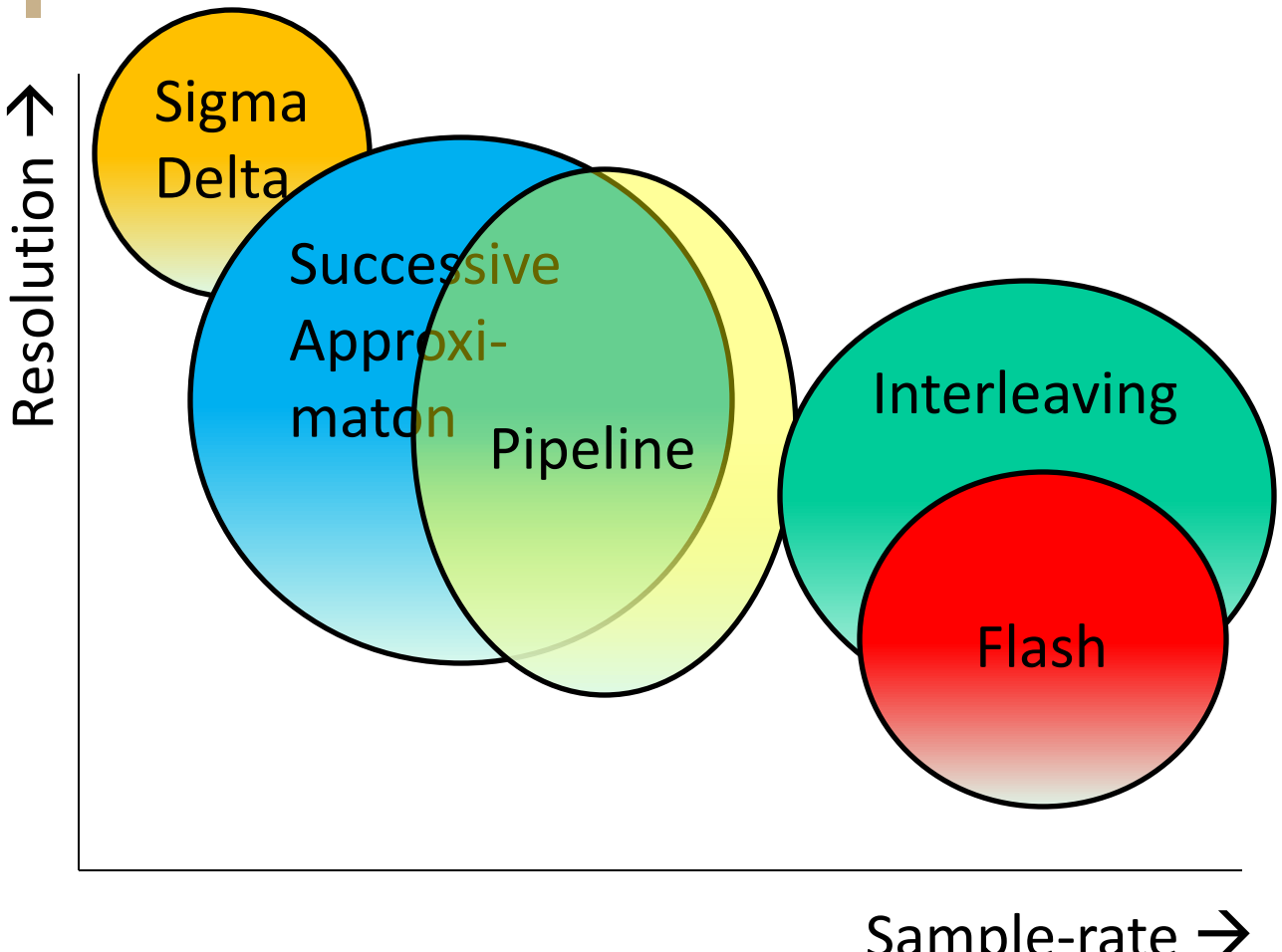


ADCs

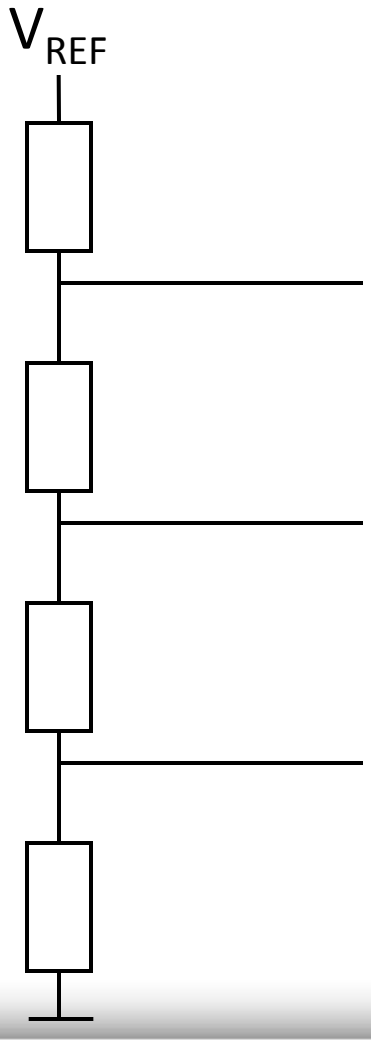
Analog to Digital Conversion



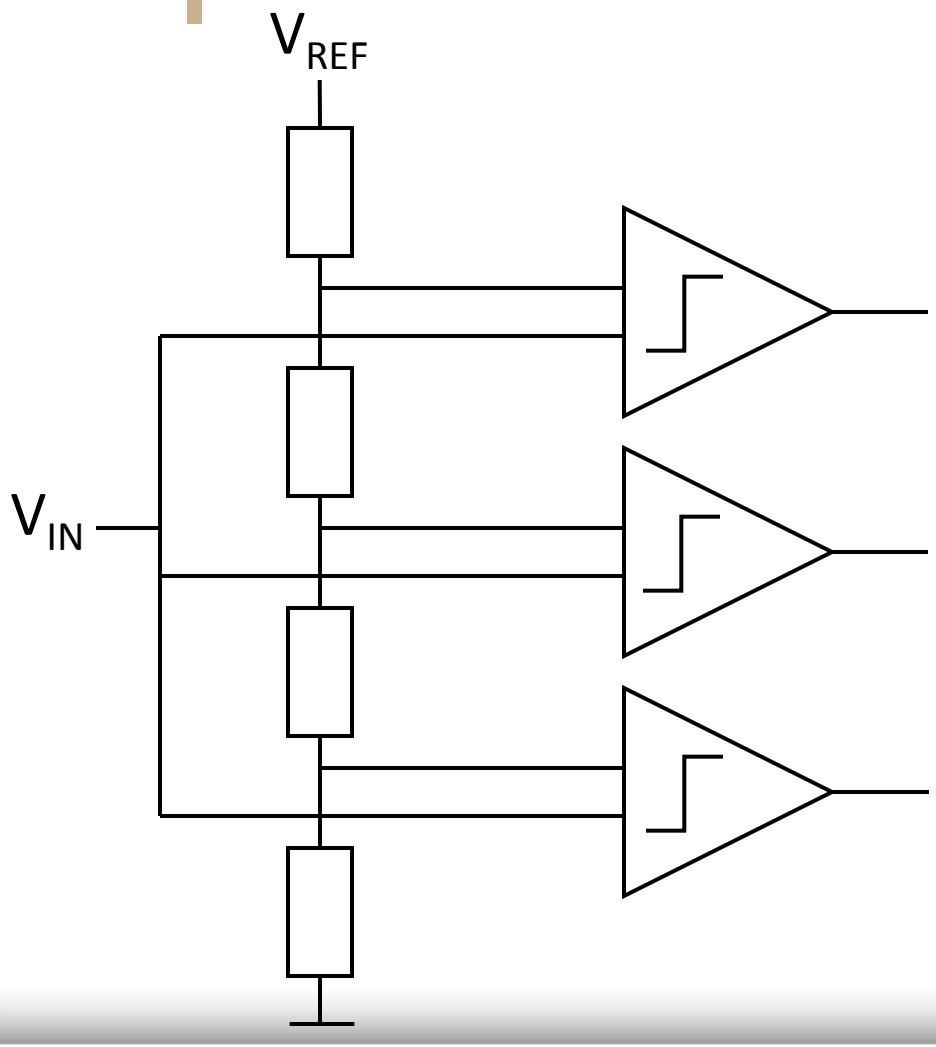
ADC architectures



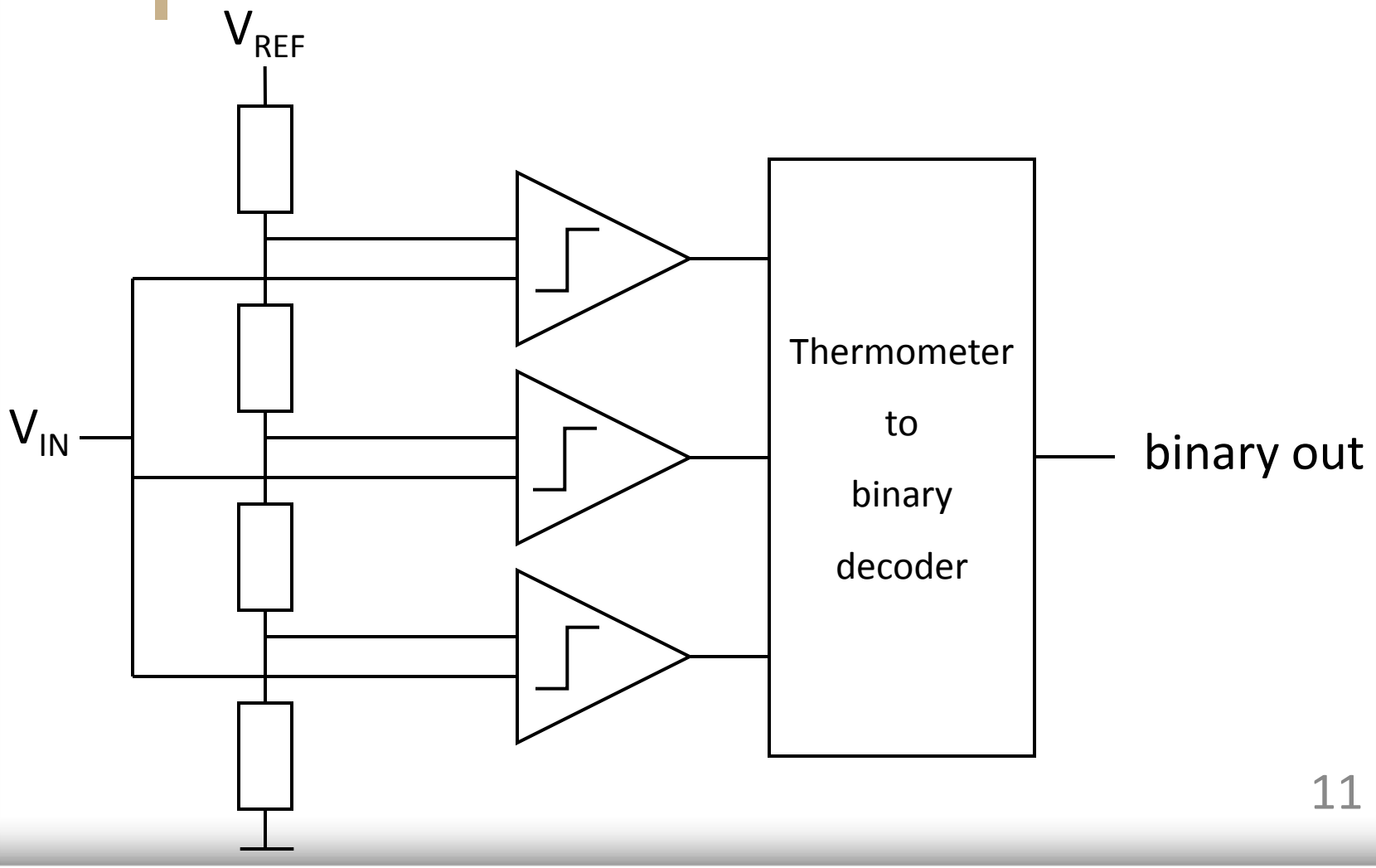
Flash ADC



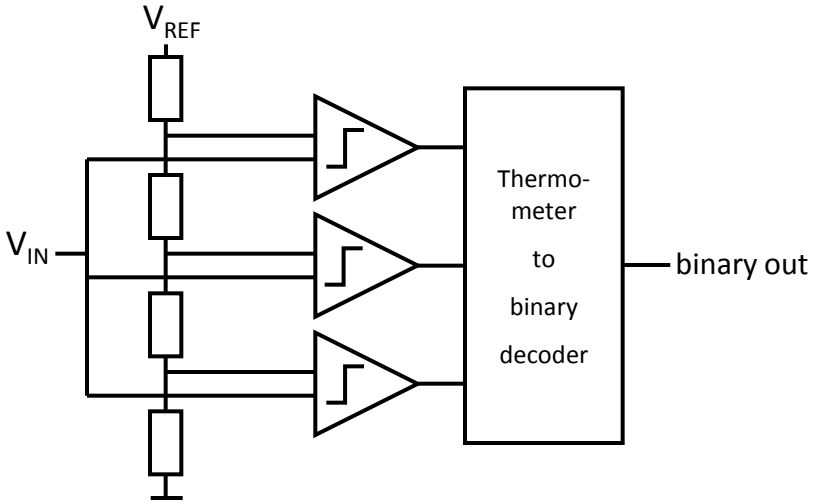
Flash ADC



Flash ADC



Flash ADC



Advantages

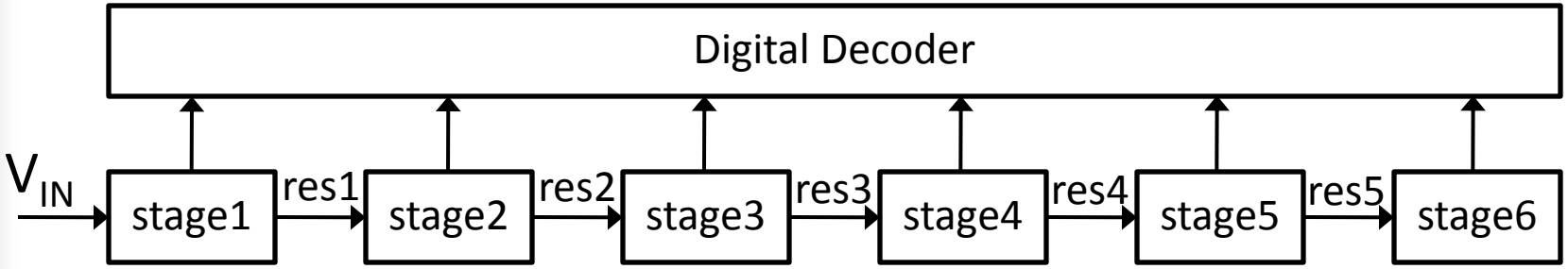
- Fast (few GS/s)

Disadvantages

- Does not scale well: #comparators = $2^n - 1$
- For large n: high power, large chip area, large input cap
- Each additional bit: 8 times more area

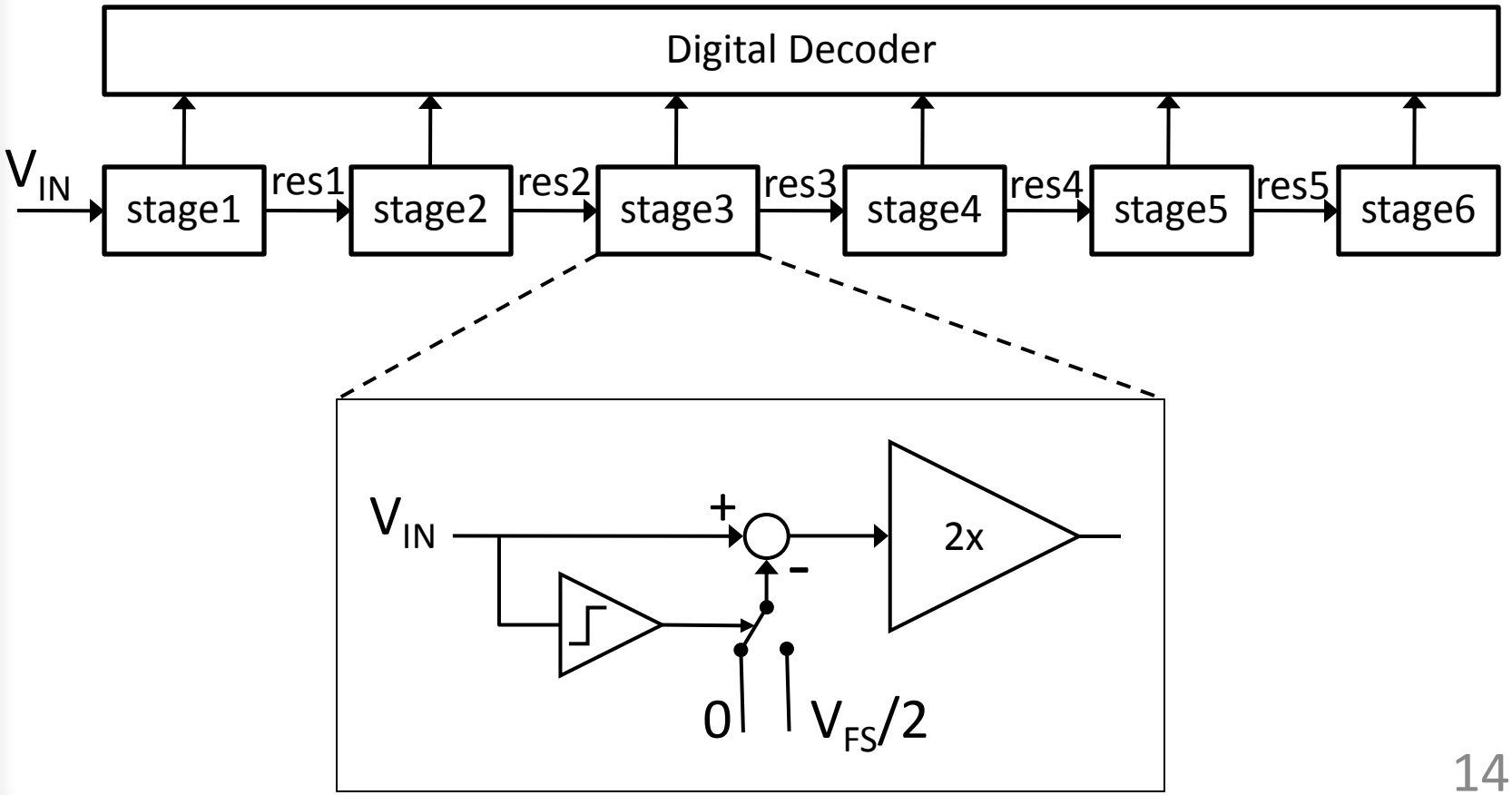
Pipeline ADC

Implementation



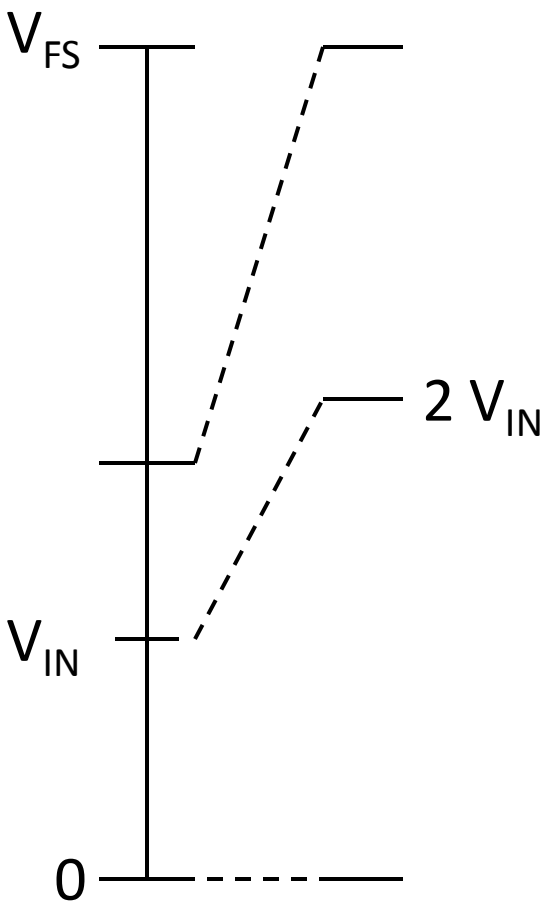
Pipeline ADC

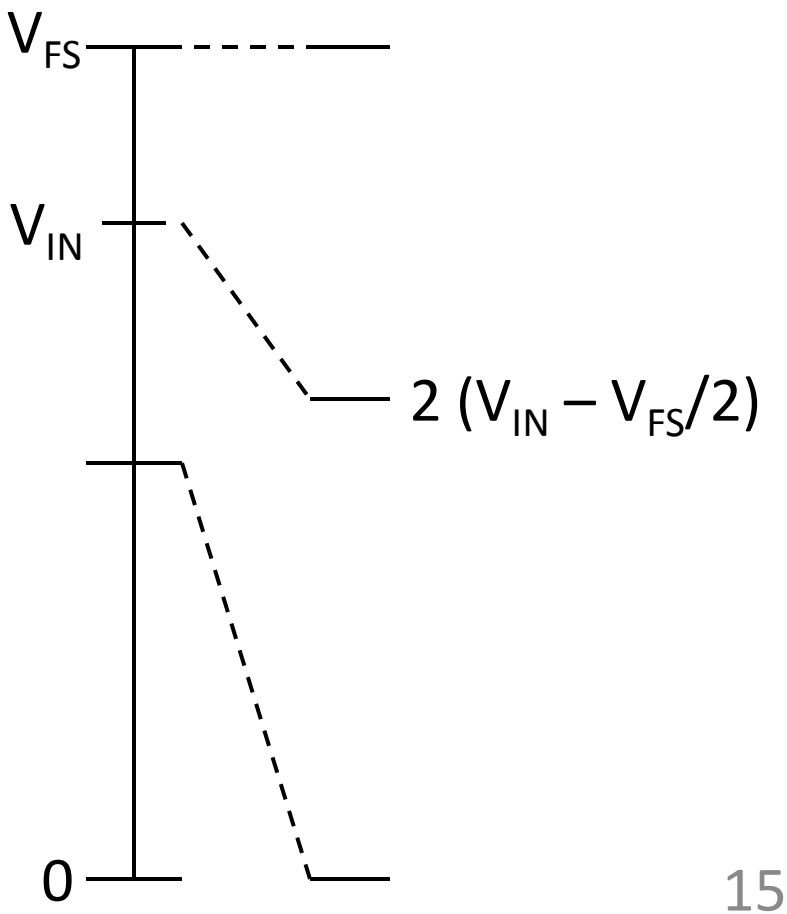
Implementation



Pipeline ADC

Signal processing





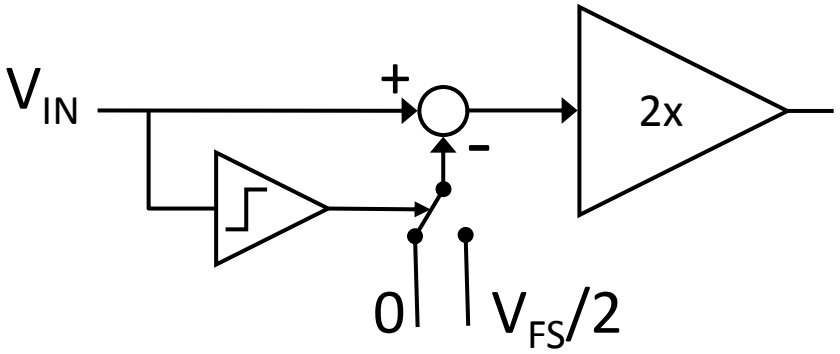
Pipeline ADC

Pros - Cons

Advantages

- Fewer comparators:

  Higher resolution possible

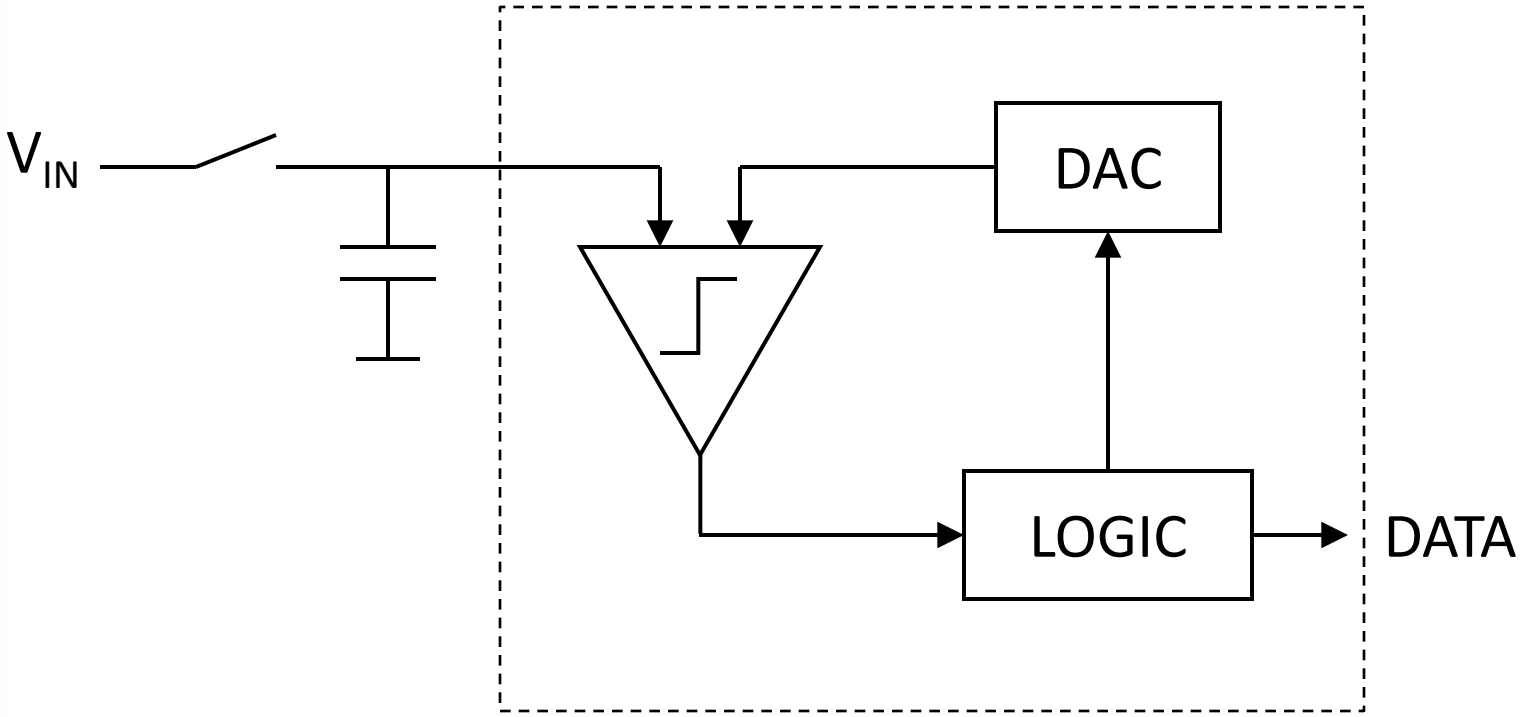


Disadvantages

- Accurate opamp!
  (high power, porting to other IC process difficult)
- Errors accumulate

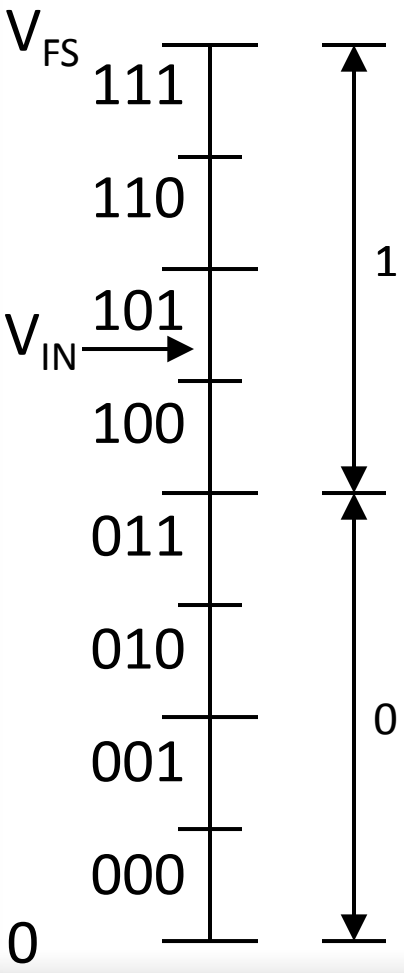
Successive Approximation ADC

Implementation



Successive Approximation ADC

Signal processing



Successive Approximation ADC

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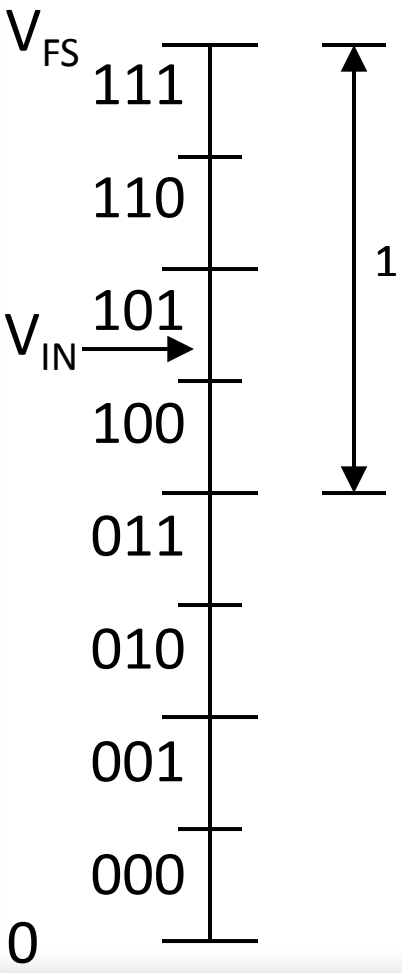
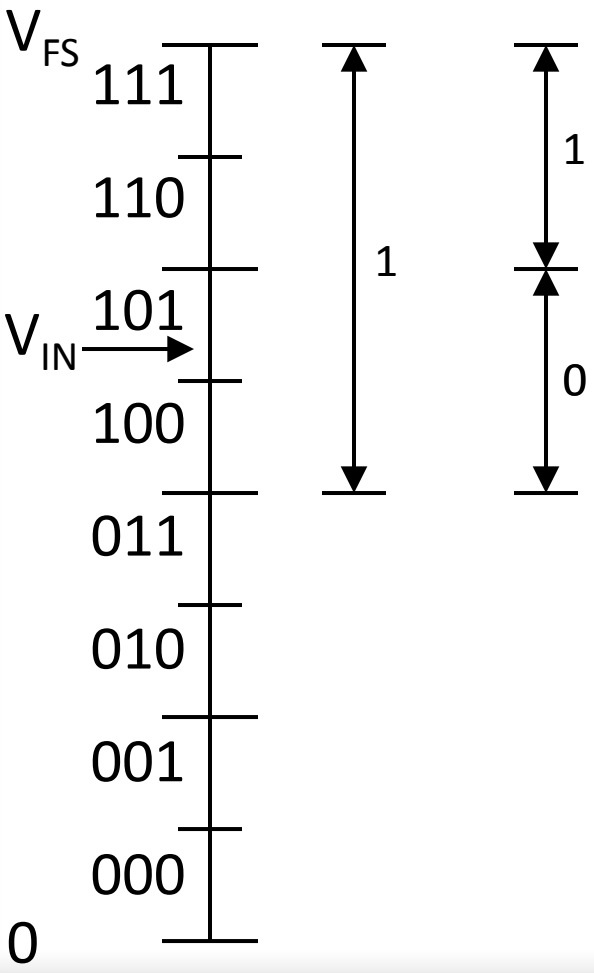


Successive Approximation ADC

Signal processing



Successive Approximation ADC

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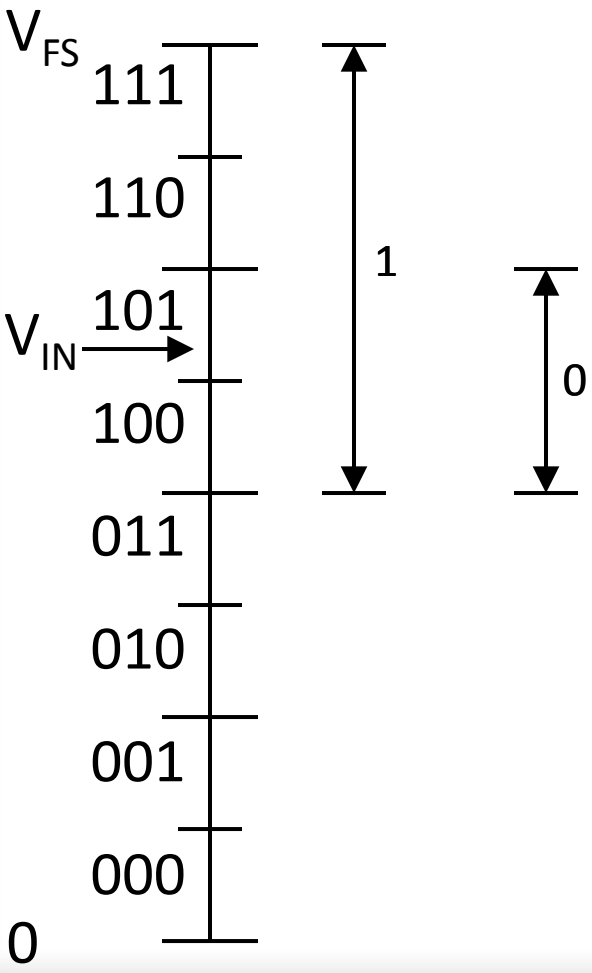

Successive Approximation ADC

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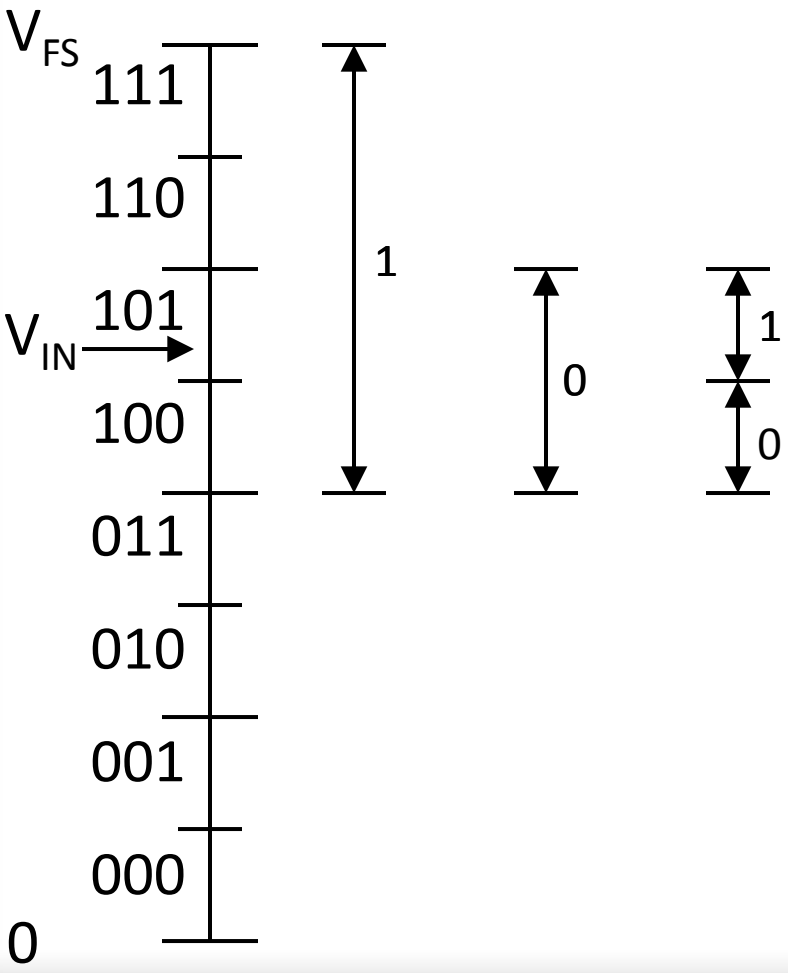
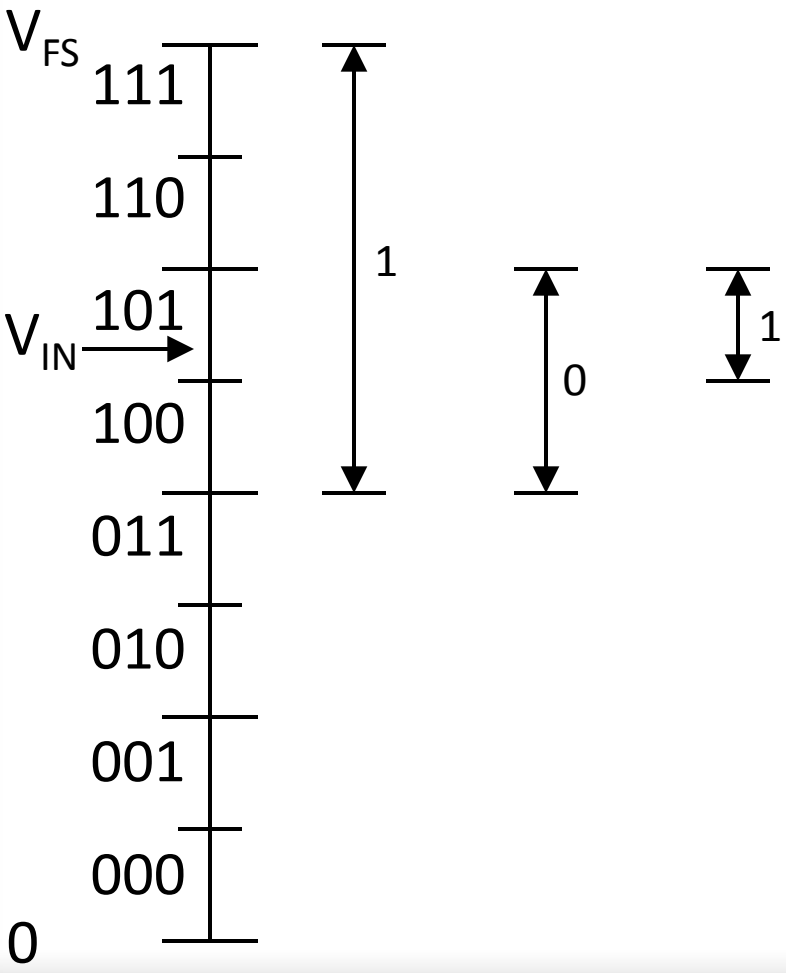
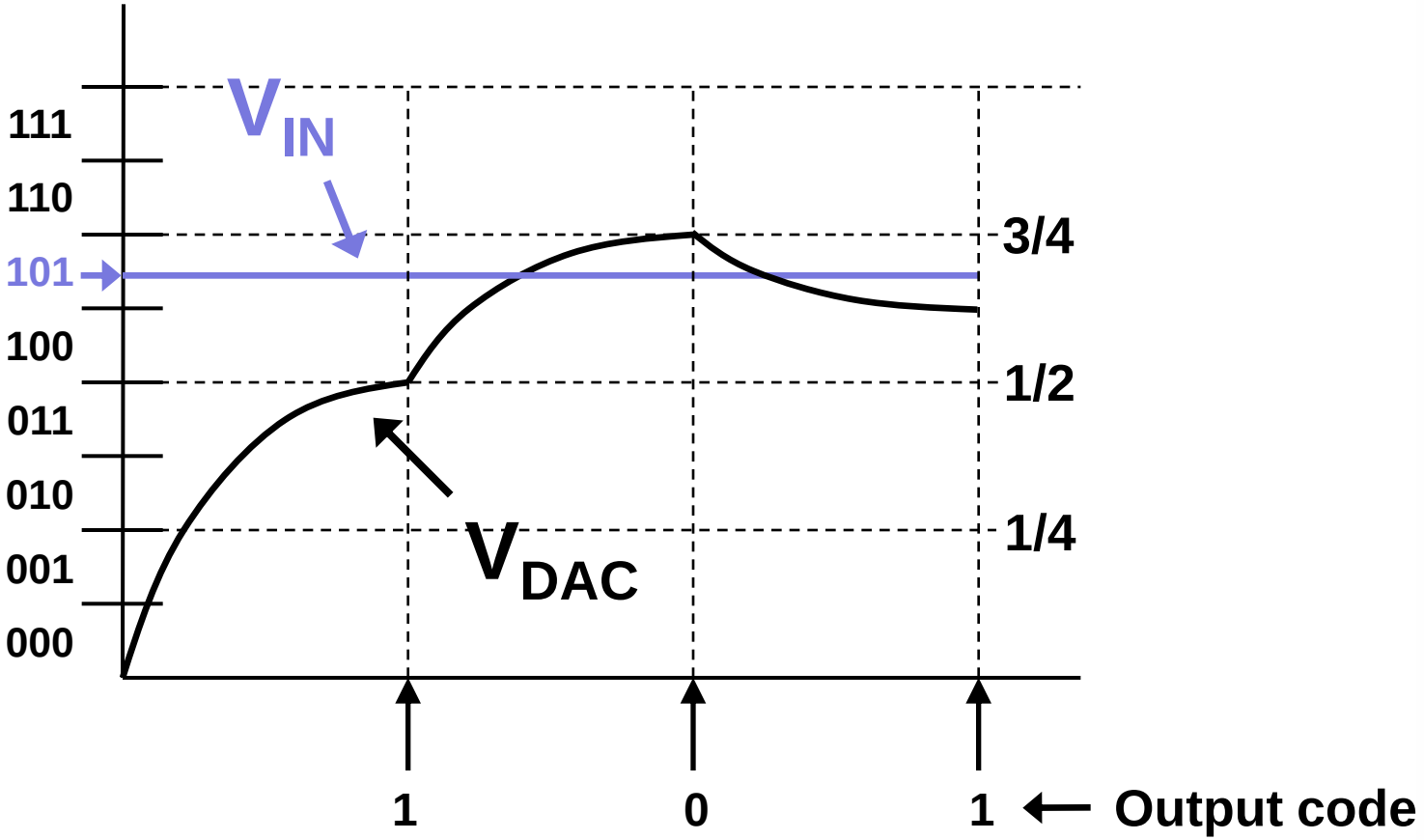


Successive Approximation ADC

Signal processing

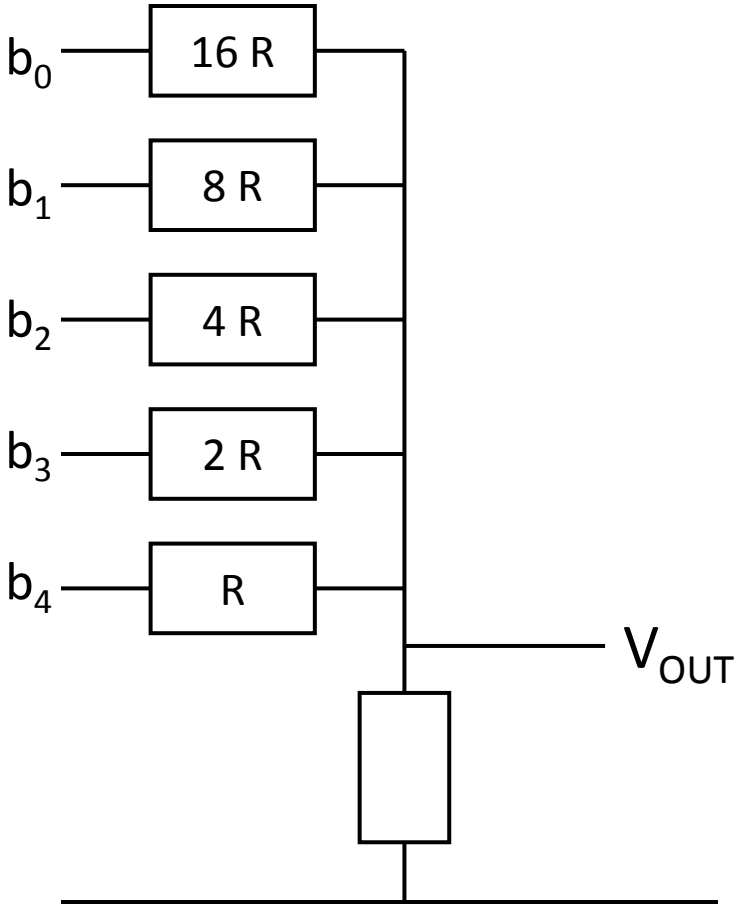


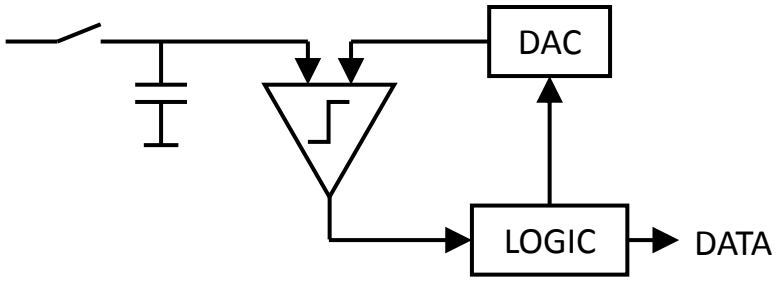
Successive Approximation ADC



Successive Approximation ADC

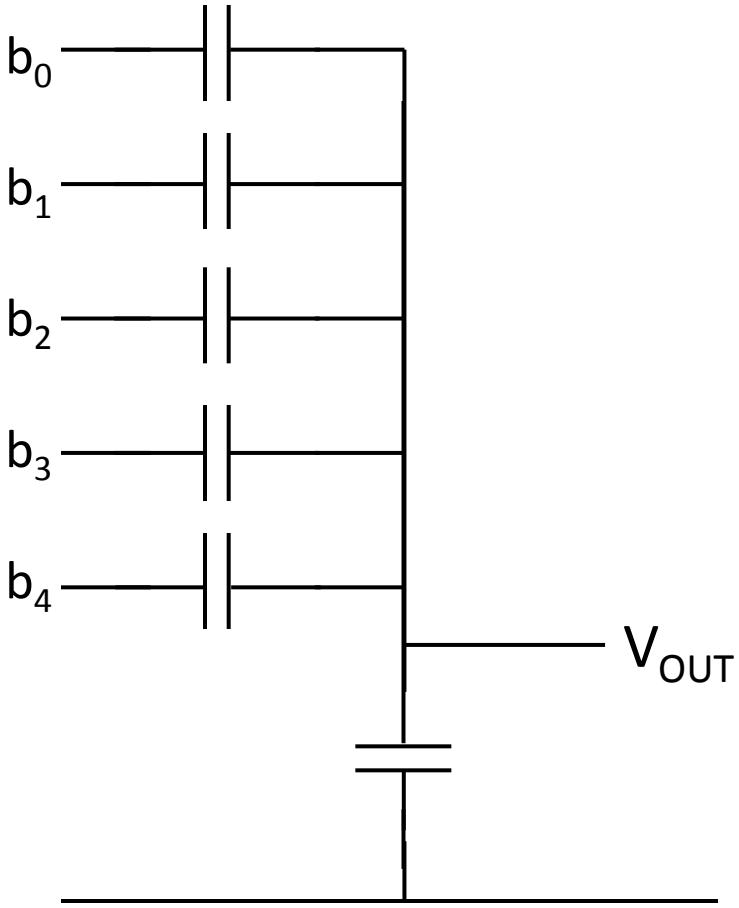
DAC implementation

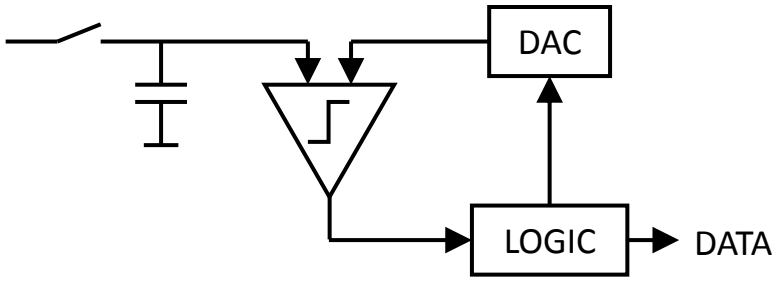




Successive Approximation ADC

DAC implementation



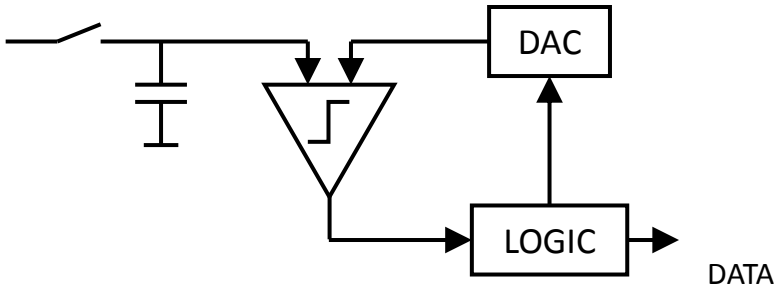


- Capacitors instead of resistors: better matching in IC process
- No static power consumption

Successive Approximation ADC

Advantages

- No opamp! Low power
- Mostly digital circuitry
- Errors do not accumulate

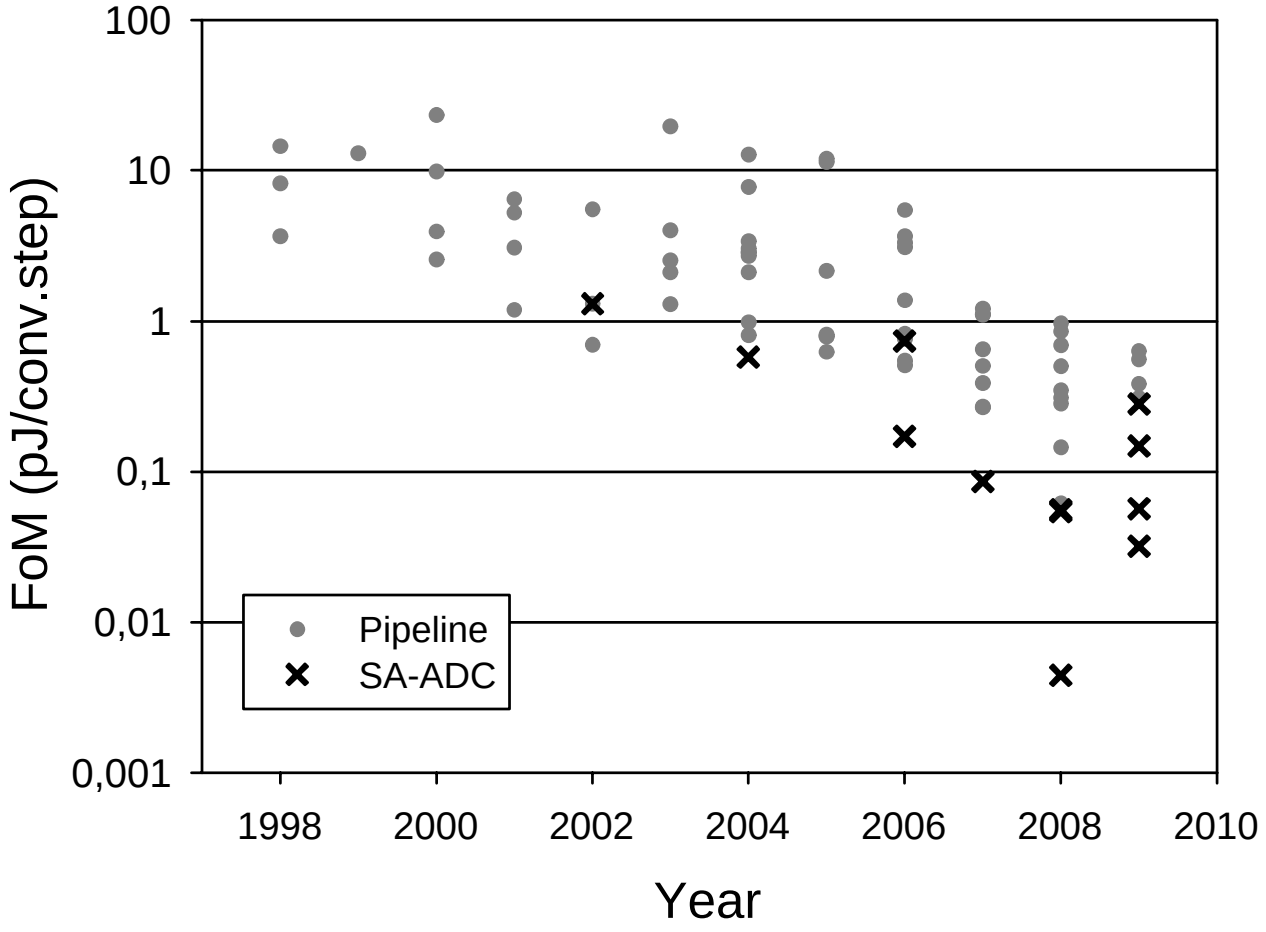


Disadvantages

- n iterations required (steps faster than pipeline)
- DAC settling and accuracy limit performance

Power efficiency

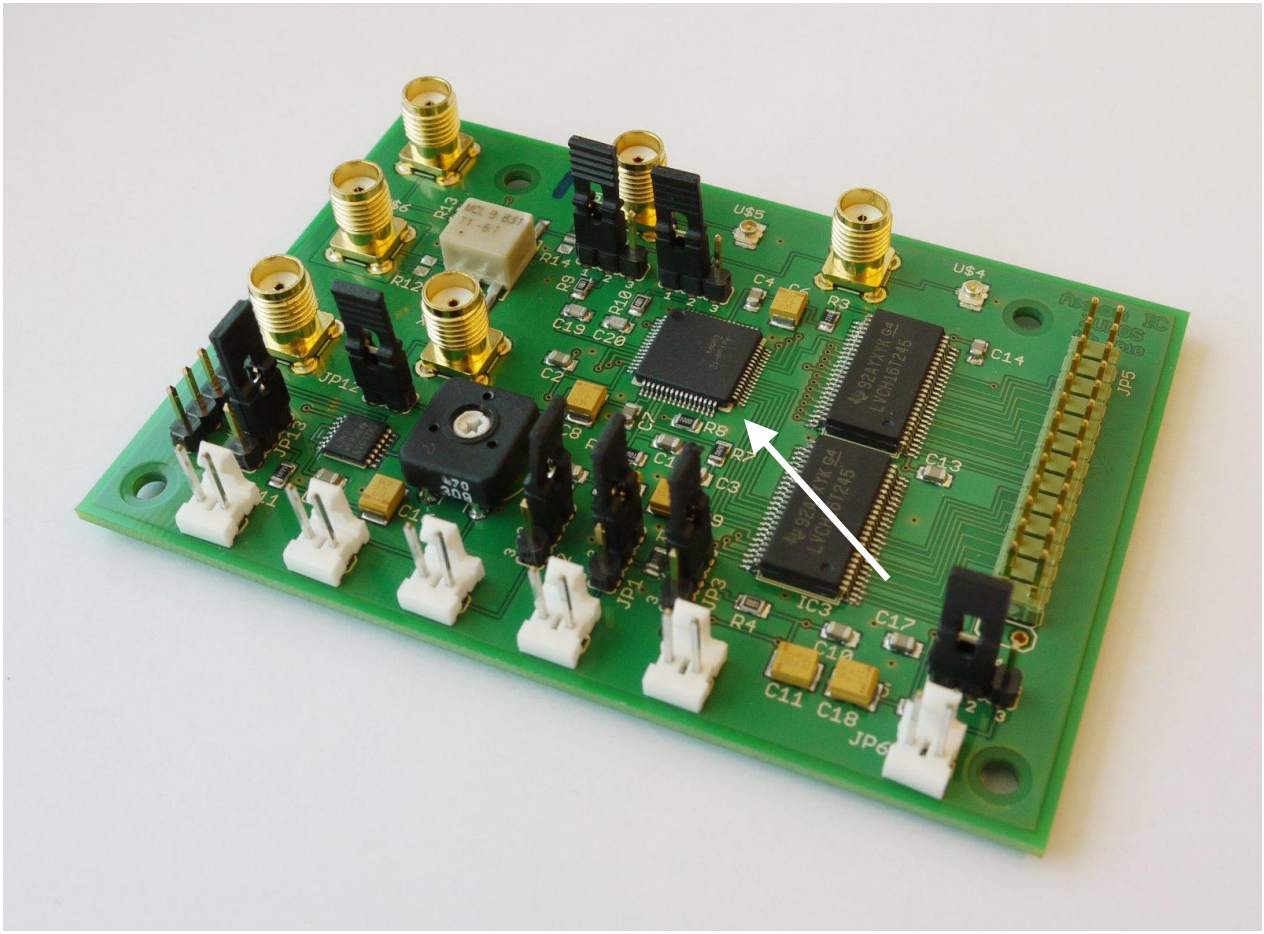
Pipeline versus Successive Approximation



B. Murmann, "ADC Performance Survey 1997-2010," Stanford

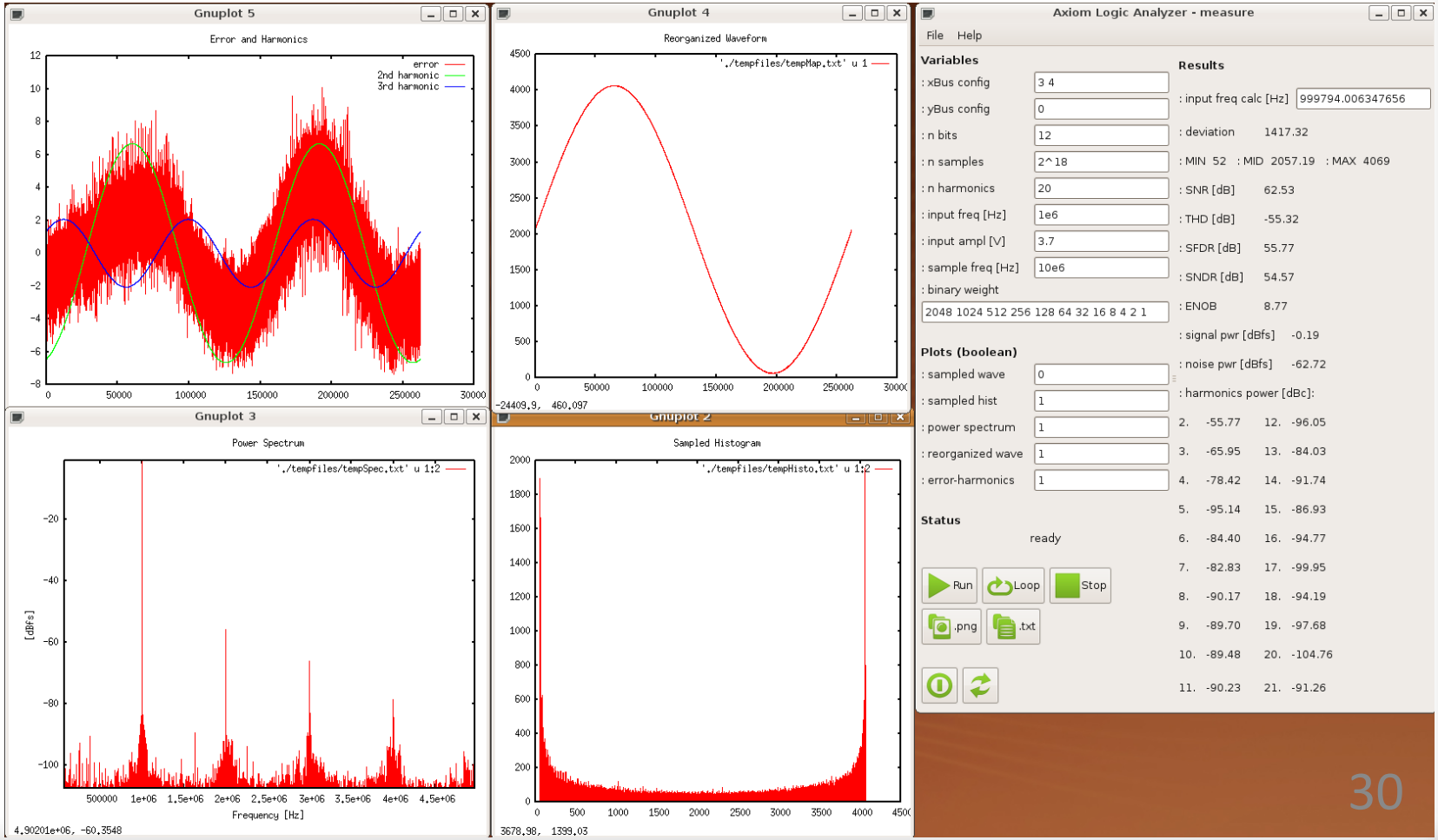
Measurements

Measurement board



Measurements

Results



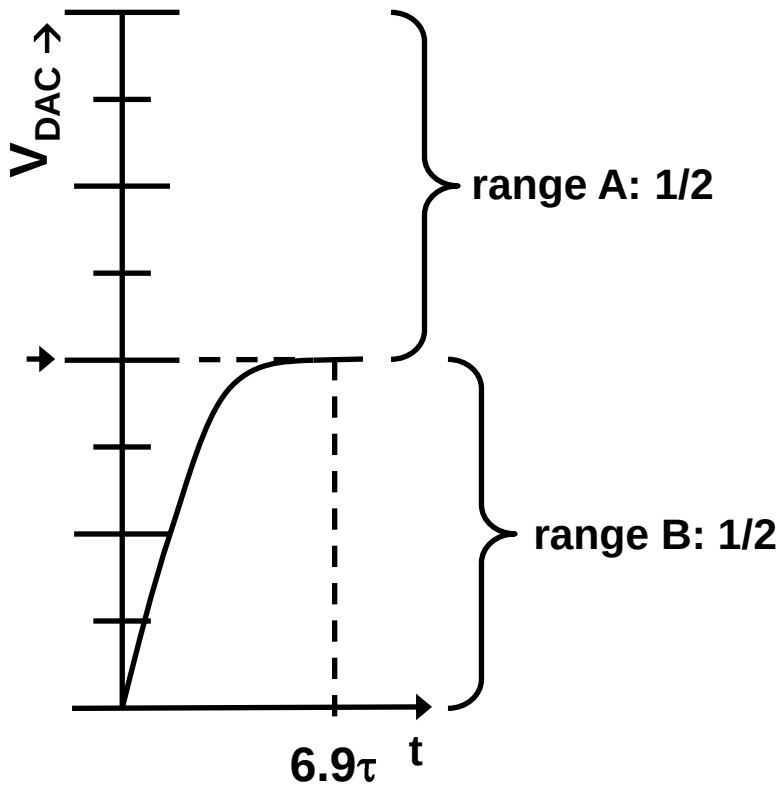
Measurements

Results

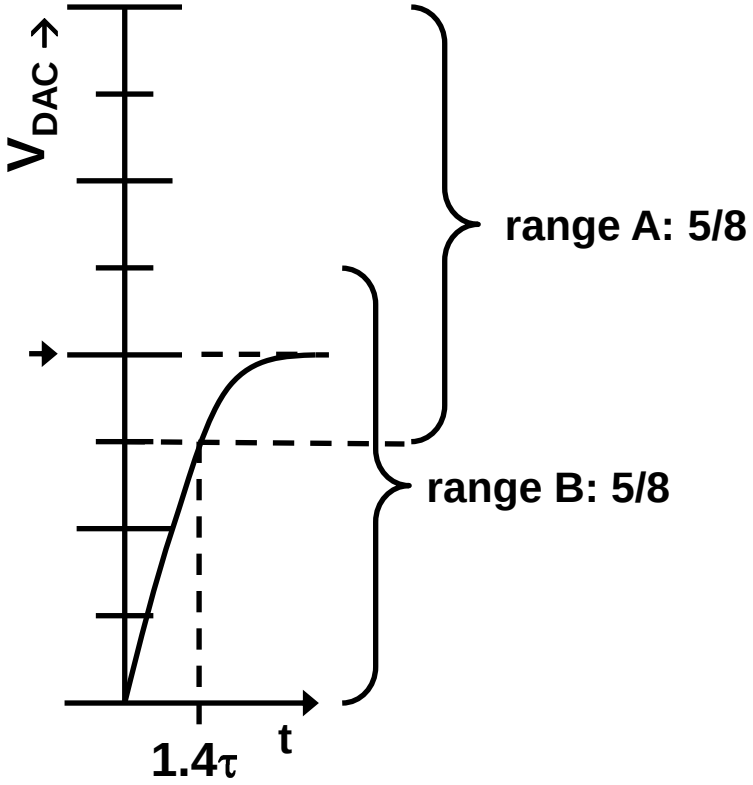
Resolution	12 bits
Sample-rate	0-10 MS/s
Accuracy	10.5 ENOB
SFDR (incl THD)	> 80 dB
Area	0.15 mm^2
Power	0.7 mW @ 10 MS/s 0.007 mW @ 100 kS/s
FoM	0.05 pJ/conv.step

Future improvements

Overranging (10 bits example)



total: 6.9τ * 10 = 69τ



total: 1.4τ * 15 = 21τ

Conclusions

- Successive Approximation ADCs significant advantages
  - No opamp → less power
  - Better portability
  - Consumes only power when needed → flexible
  - Working on higher sample-rates

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