Quantization theory

1. Quantization: transformation of analog signals to discrete outputs

2. Coding: Assign the outputs to a digital code.

Analog - to - Digital converters (A/D)

8-bit, 10-bit, 12-bit, ...

Resolution : 2^n n: bits of A/D converter.

Example 1: 3-bit A/D : $2^3 = 8$ levels. (Resolution)

Example 2:

The input voltage is in the range of 0 - 4 V. How can we use a 3-bit A/D converter to analyze the input voltage

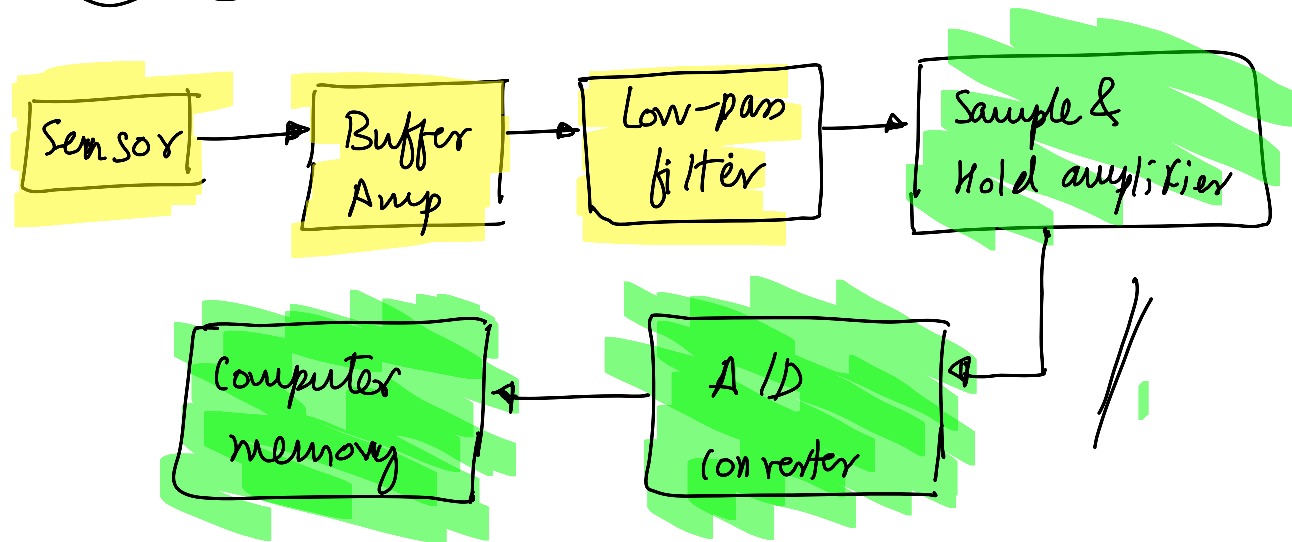
Number of levels $= 2^3 = 8$

Quantization Voltage	State	Coding Binary code
0-0.5	1	000
0.5-1	2	001
1-1.5	3	010
1.5-2	4	011
2-2.5	5	100
2.5-3	6	101
3-3.5	7	110
3.5-4	8	111

- Input voltage = 3.2 V $\Rightarrow$ Code 110
- Quantization size $= \dfrac{V_{max} - V_{in}}{2^n} \Rightarrow \dfrac{4-0}{2^3} = 0.5V$

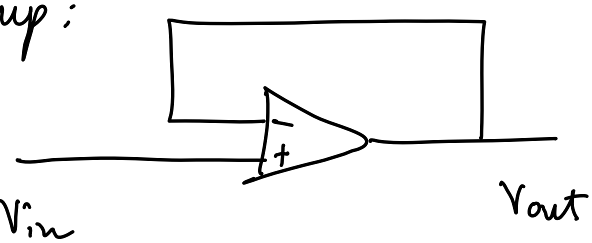
Using a 10-bit $\Rightarrow \dfrac{4-0}{2^{10}} \approx 0.004\ V$

Analog-to-Digital Conversion



1) Sensor: measures physical quantity
& converts to voltage

2) Buffer amp:

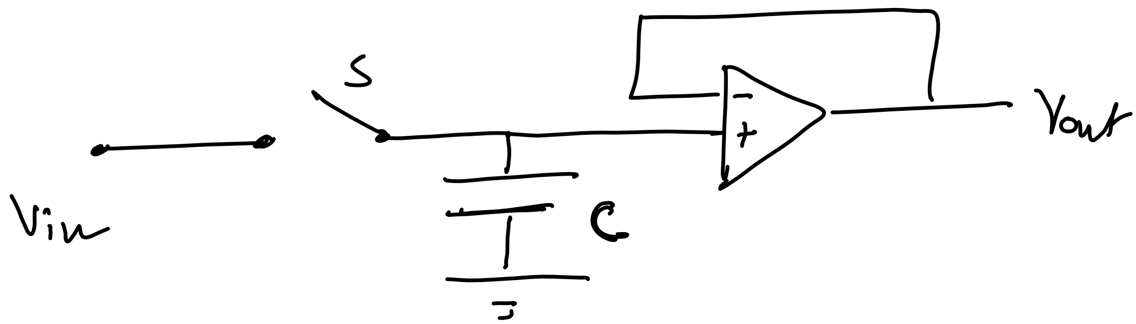


a) non-inverting op-amp
b) amplify & isolate the output from input

3) low-pass filter: assumes the V_{in} has
high frequency noise

RC

4) Sample and hold amplifier



holds the input for the A/D &
compute memory

5) A/D converter

- convert analog signal to digital
signal

6) Computer memory

save data.

Analog to Digital Converters

① Successive approximation converter
② Flash Converter

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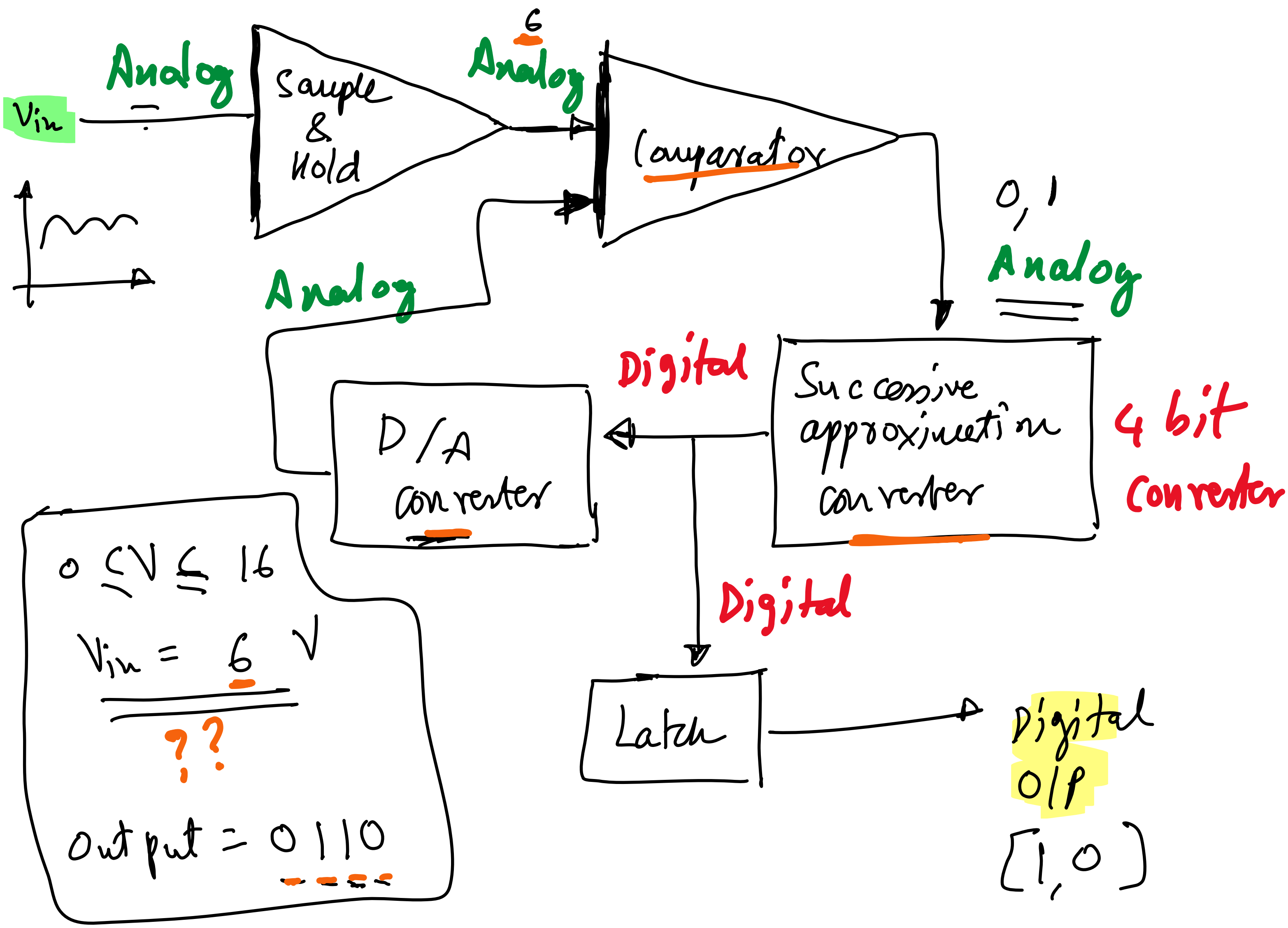
① Successive approximation converter



$$\overset{3\ 2\ 1\ 0}{6\,V \Rightarrow 0\,1\,1\,0}$$

$$\underline{0(2^3) + 1(2^2) + 1(2^1) + 0(2^0)} = 0 + 4 + 2 + 0 = 6$$

Working

0–16 V

① $V_{in} = 6\,V$

comparator : compare 6 V against $\frac{1}{2^1}(16)$

$6\,V < 8\,V$

output = 0

② comparator : compare 6 V agains $\frac{1}{2^2}(16)$

$6\,V \geq 4\,V$

output = 1

③ comparator : compares 6 V against $\frac{1}{2^3}16 + 4$

$6\,V \geq 6\,V$ D/A

output = 1

④ compare 6V against $6 + \frac{1}{2^4}(16) =$

$$6V \leq 7V$$

output = $\underline{\underline{0}}$

From ①, ②, ③, ④

Digital output = $0\,1\,\underline{1}\,\underline{0}$

4 1

⇒ It took 4 cycles to interpret the 4 digits. For n-bits, it will take a time of nT

← clock

This is time consuming (DIS)

⇒ ADVANTAGE: Require very few electronic components.