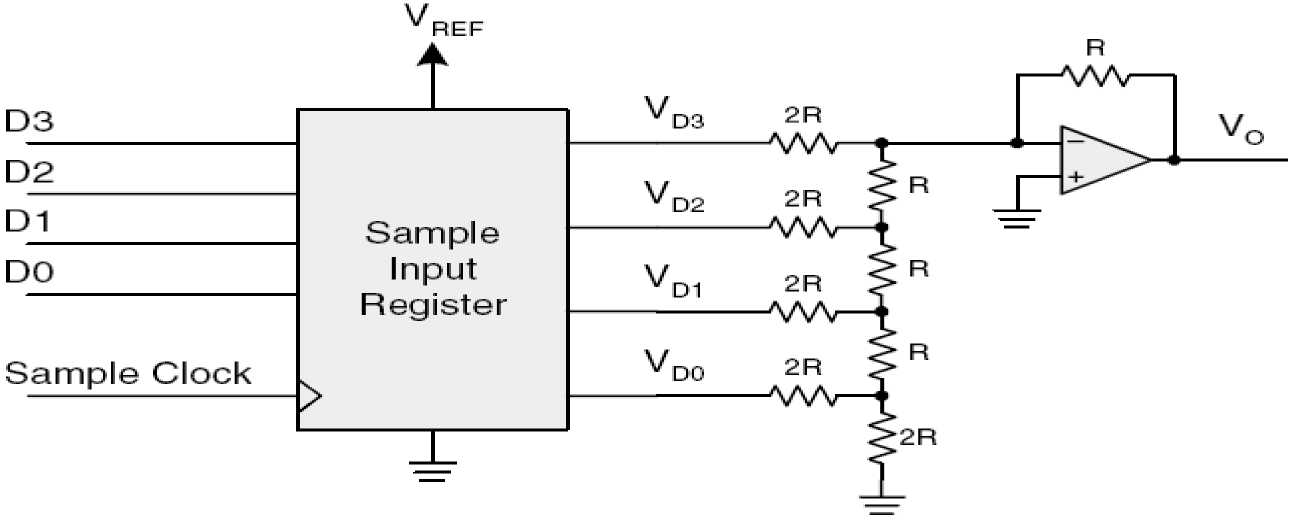
Data conversion:
ADC / DAC

Digital-to-Analog Converter (DAC)



$$V_O = -V_{REF}\left[\frac{D3}{2} + \frac{D2}{4} + \frac{D1}{8} + \frac{D0}{16}\right]$$

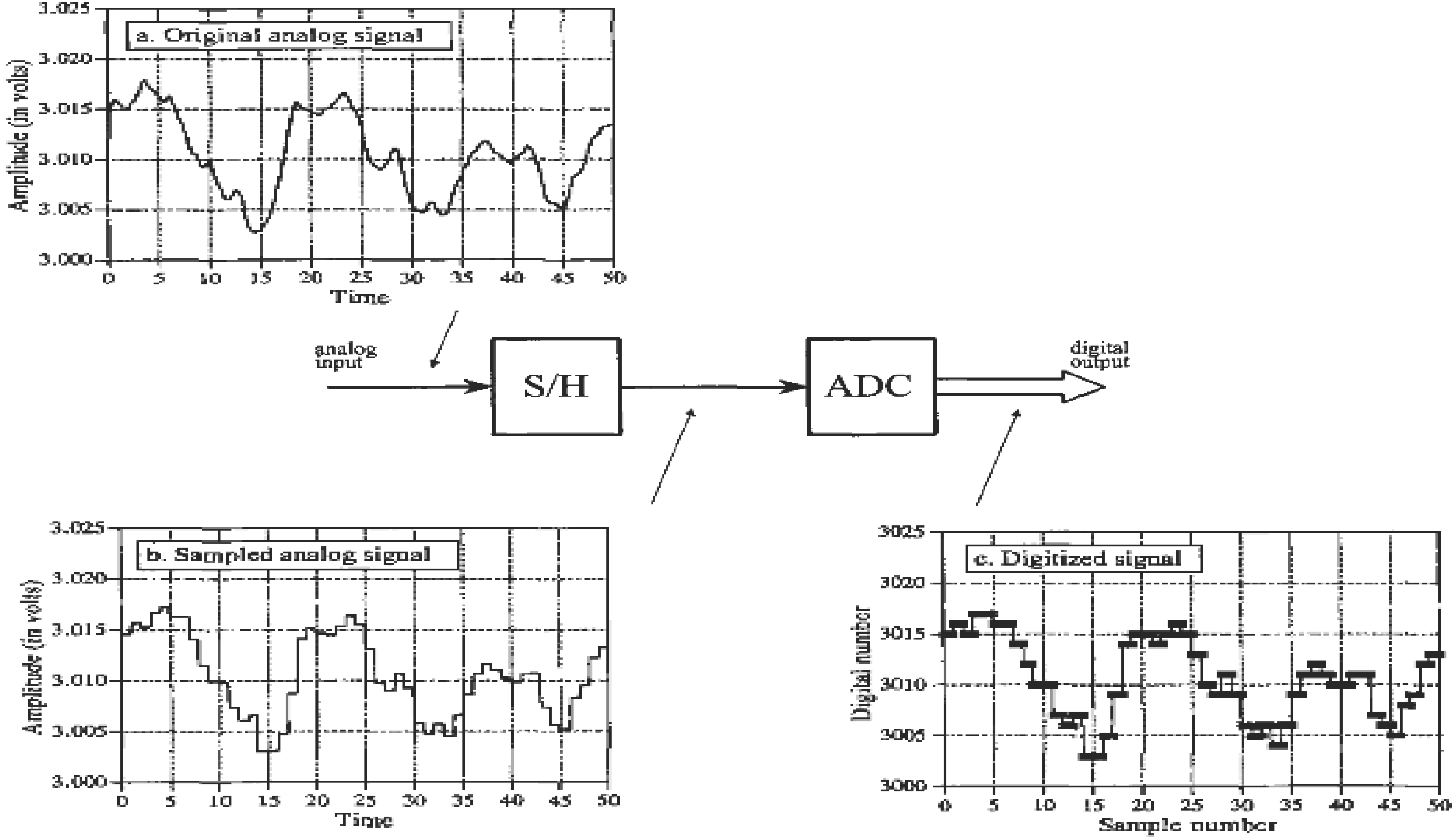
Analog-to-Digital Conversion

Analog-to-digital conversion (ADC) and digital-to-analog conversion (DAC) are the processes that allow digital computers to interact with everyday signals: voltage, current, distance, velocity, temperature, altitude, force, acceleration, pressure etc.

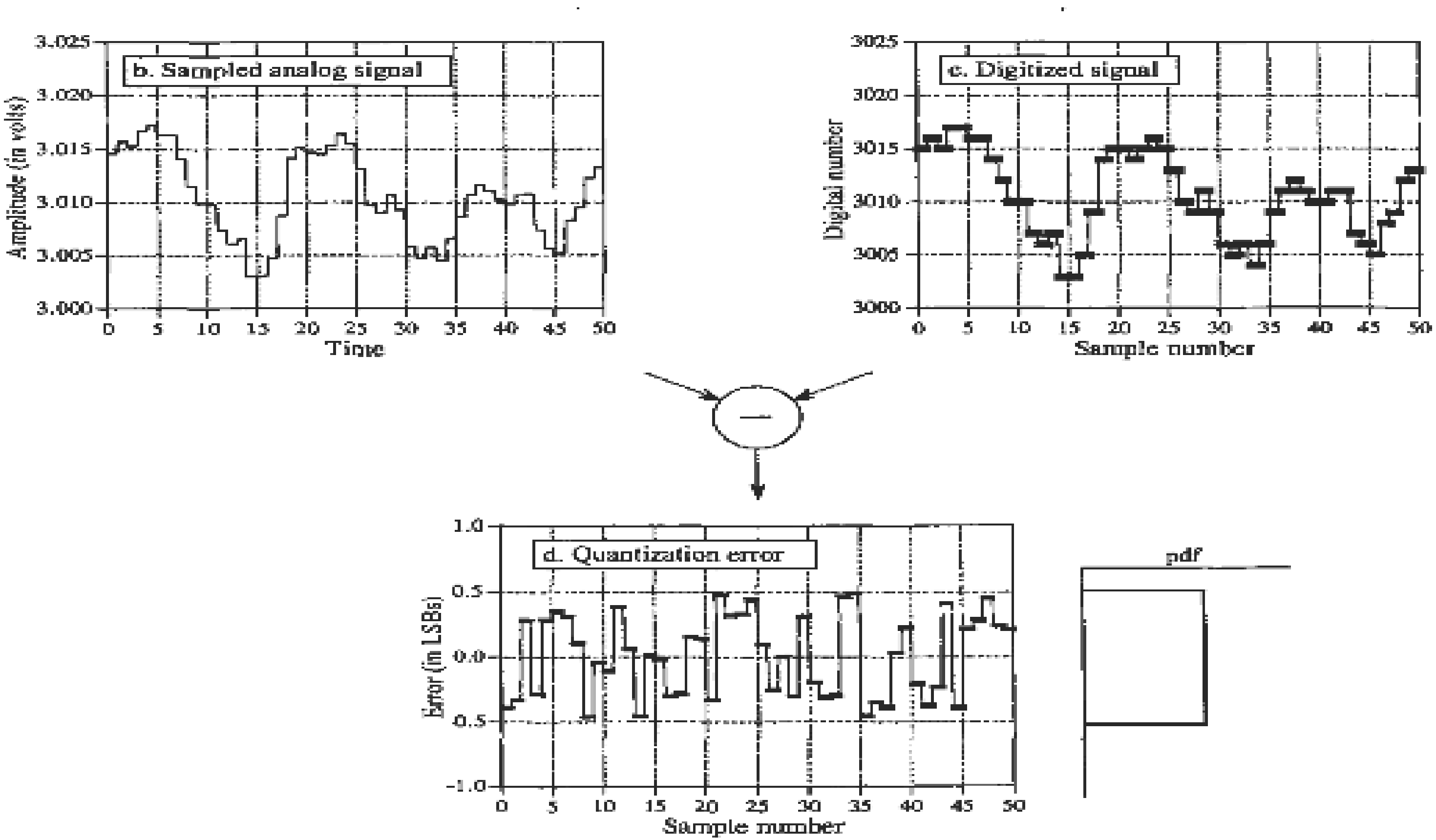
Digital information is different from its analog counterpart in two respects:

- it is *sampled*
- it is *quantized*

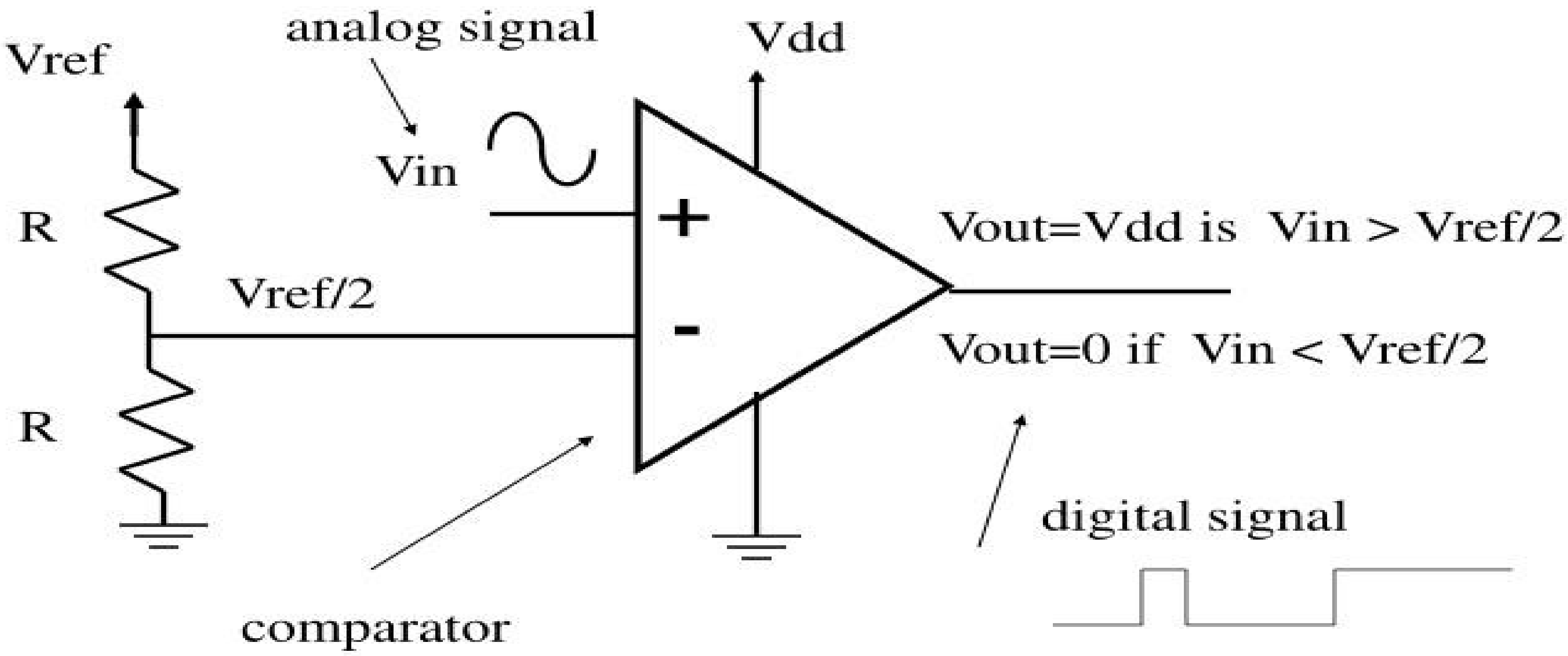
ADC Principles: S/H and Quantization



Quantization Error



A 1-bit ADC


Vref
analog signal
Vdd
Vin
R
+
Vout=Vdd is Vin > Vref/2
Vref/2
-
Vout=0 if Vin < Vref/2
R
digital signal
comparator

1-bit ADC

- Analog signal range: 0 – 5 v
- Vref = 2.5 v
- Vdd = 5 v

Vin: 0 – 2.5 v --> Vout: 0 v (FALSE)

Vin: 2.5 – 5 v --> Vout: 5 v (TRUE)

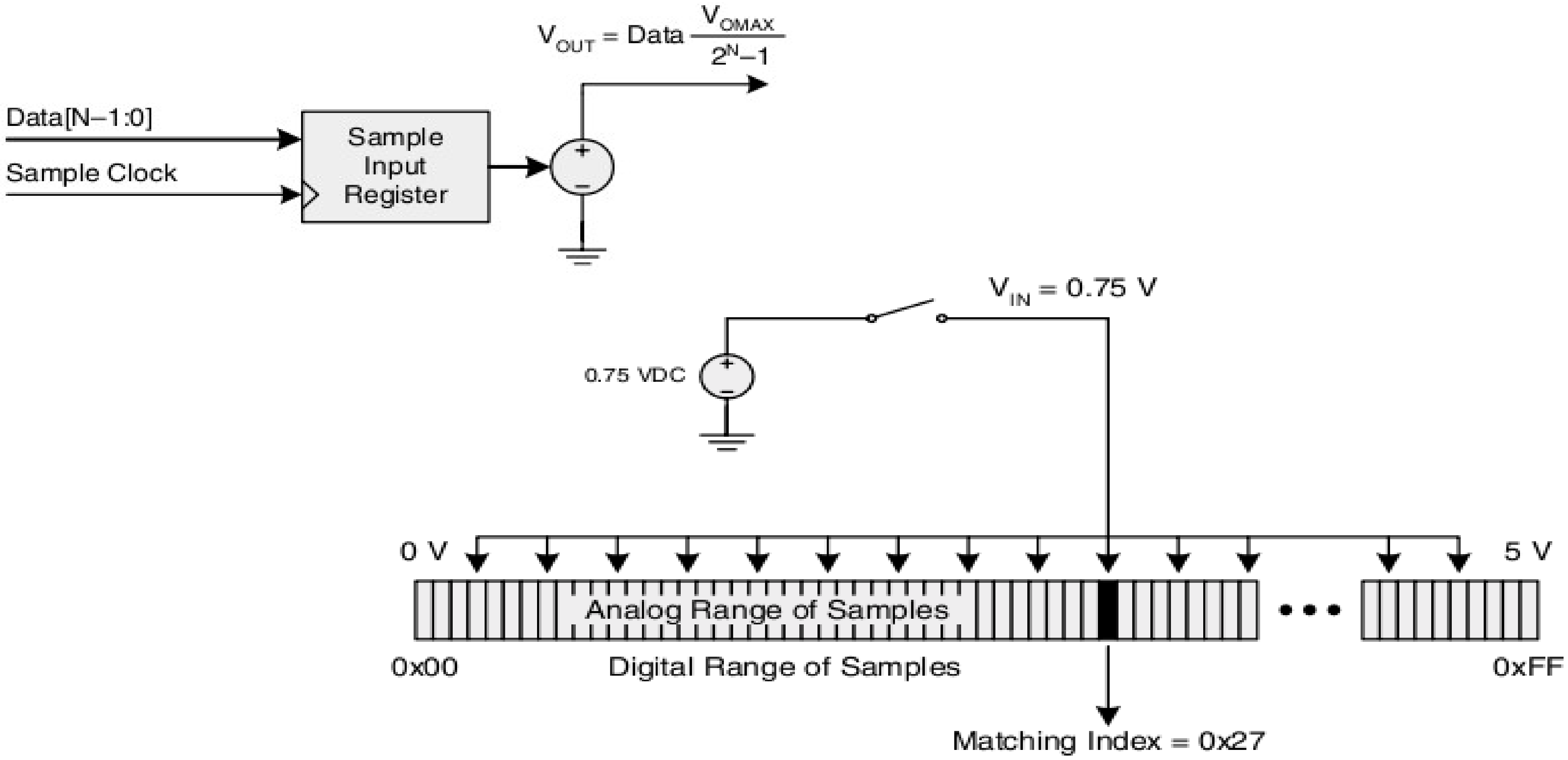
Resolution: 2

Example:

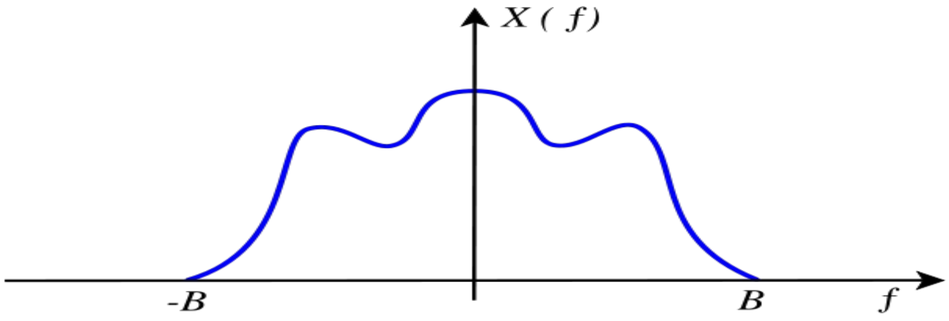
Vin=3.8 v

- What is the output of 1-bit ADC?
- What is the quantization error?

Analog-to-Digital Conversion



Sampling Theory

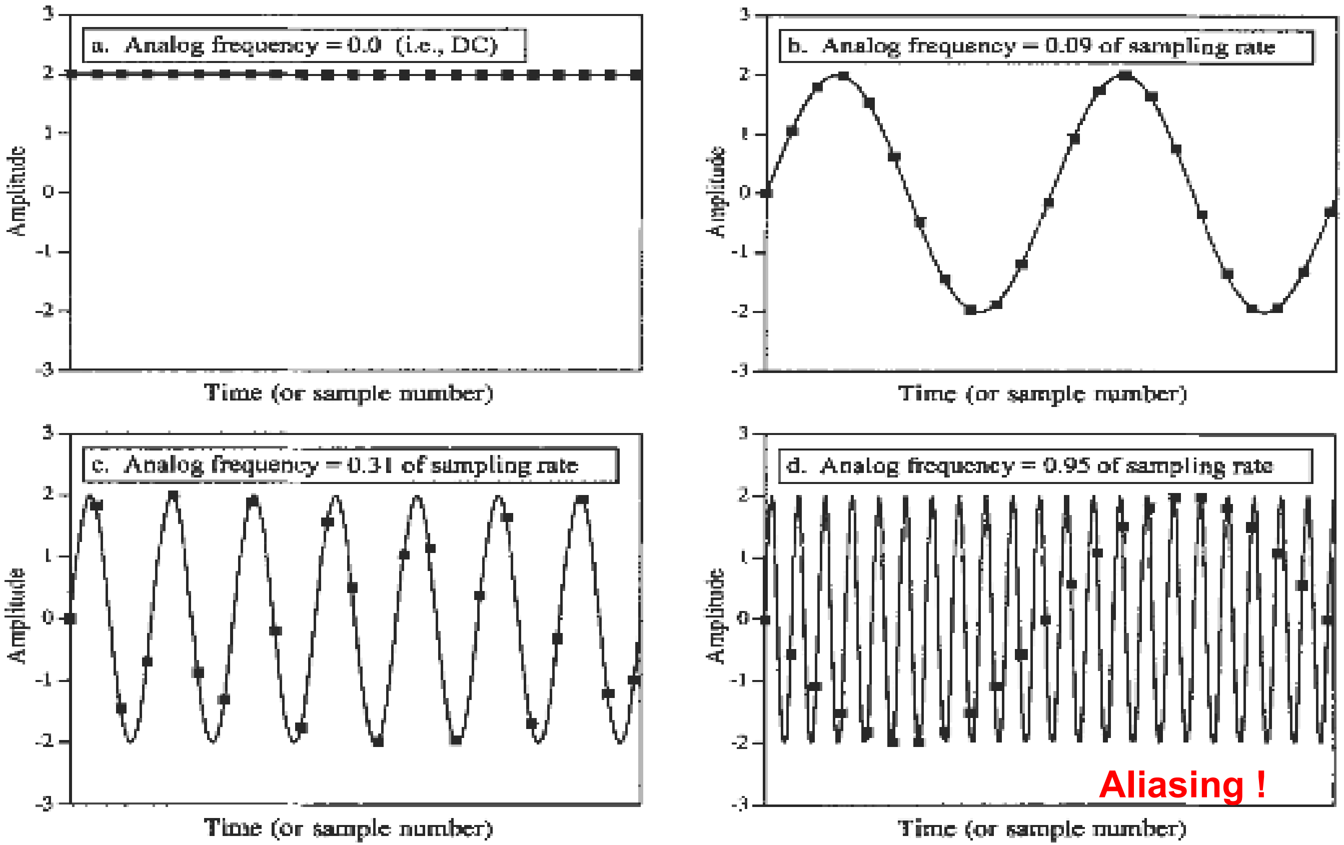


Nyquist theorem:

Analog signal that has been digitized can be perfectly reconstructed if the sampling rate was 1/(2W) seconds,

where W is the highest frequency in the original signal.

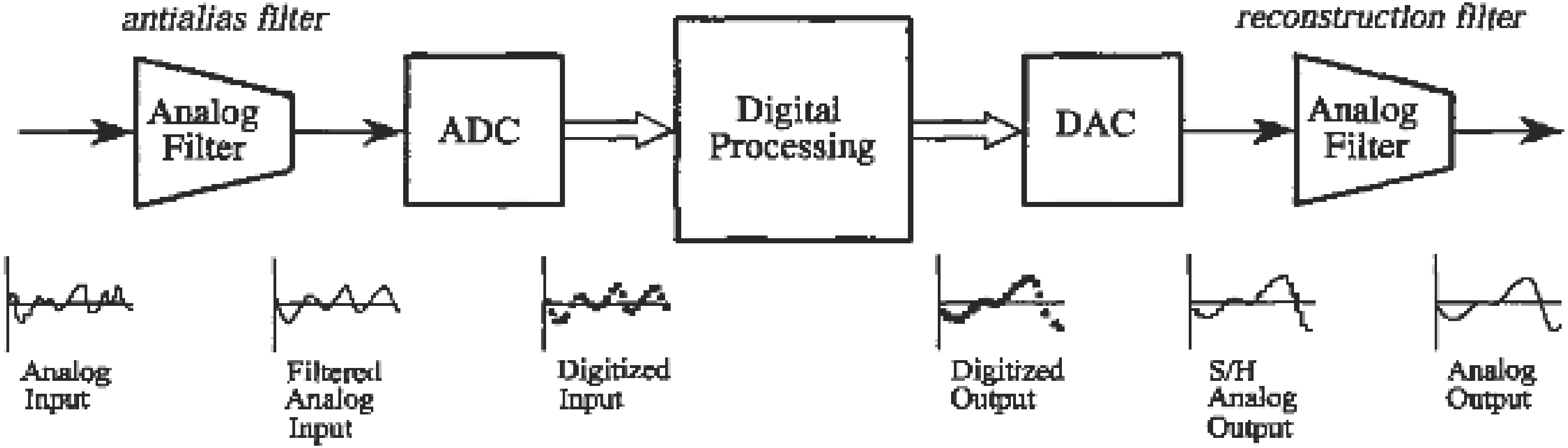
Sampling Theory



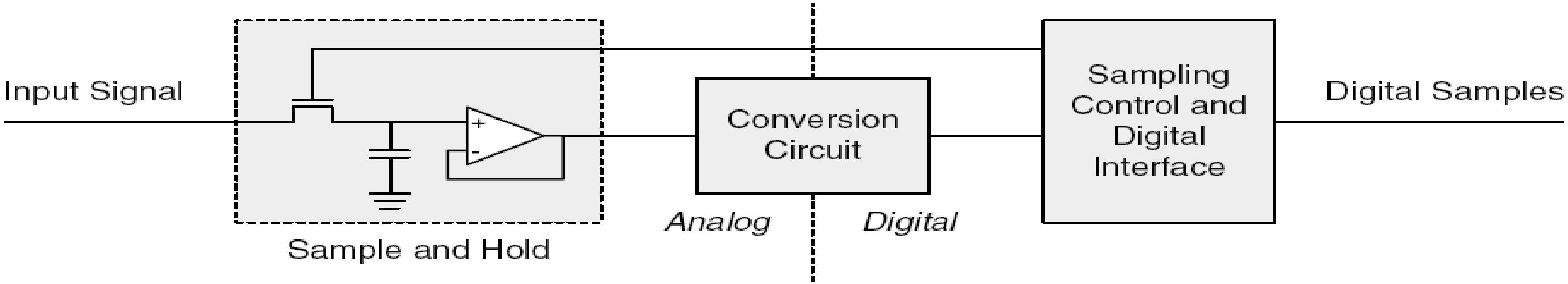
1. *Run adc.py*

2. *Evaluate the ADC with different parameters and discuss*

Using Analog Filters



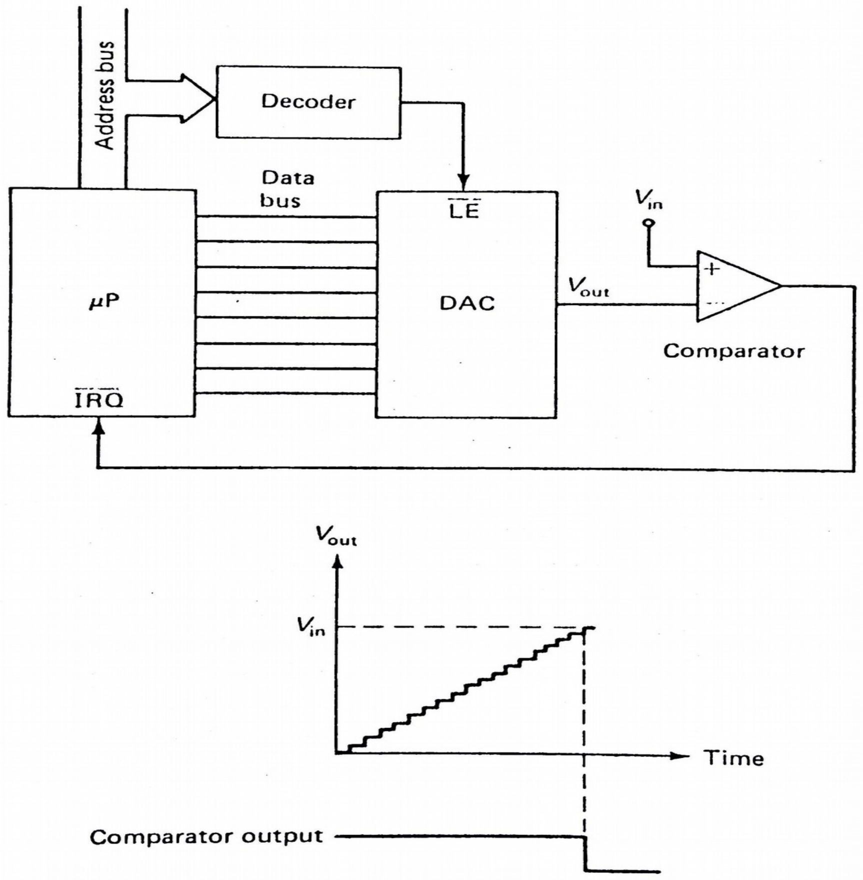
Basic A/D Architecture



ADC Types:

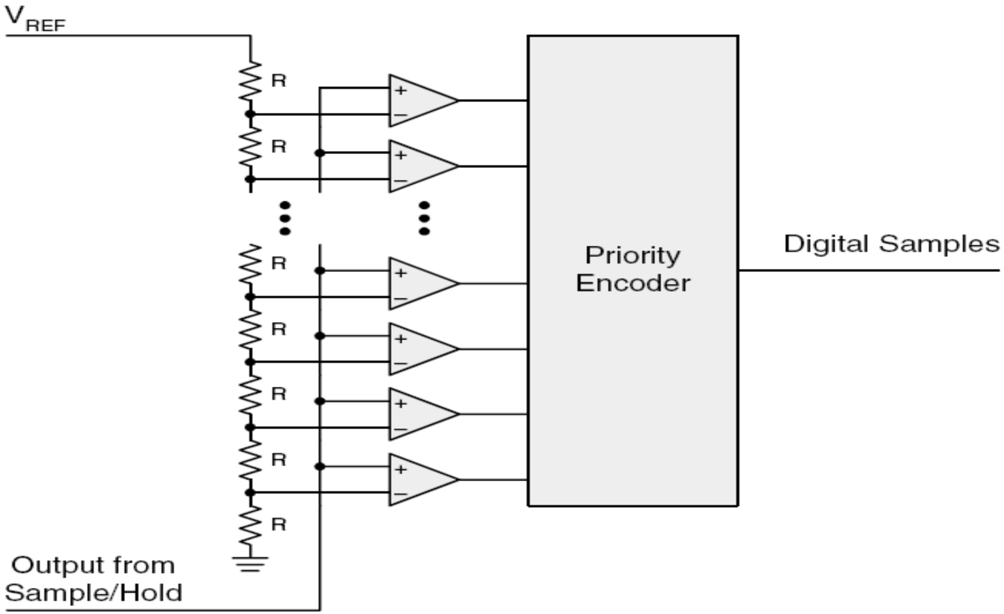
- Ramp ADC
- Flash ADC
- Succesive-approximation ADC
- Sigma-delta ADC

Ramp ADC



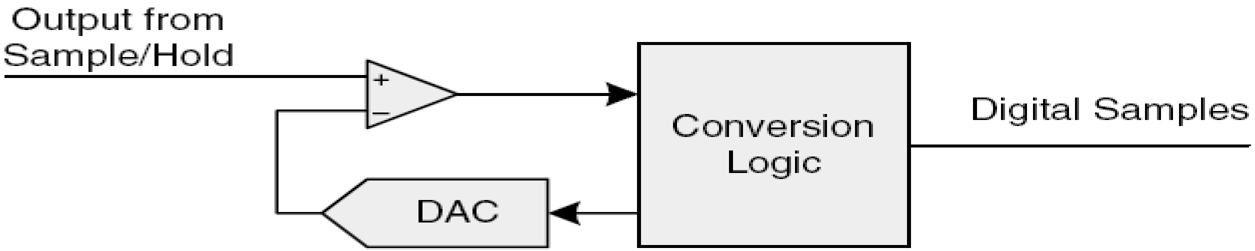
n-bit ADC requires 2^n cycles to perform a conversion in worst case.

Flash ADC



- Requires 4095 parallel comparators for 12-bit.
- Very fast, conversion is done in one step.
- Complexity doubles with each added bit of resolution.

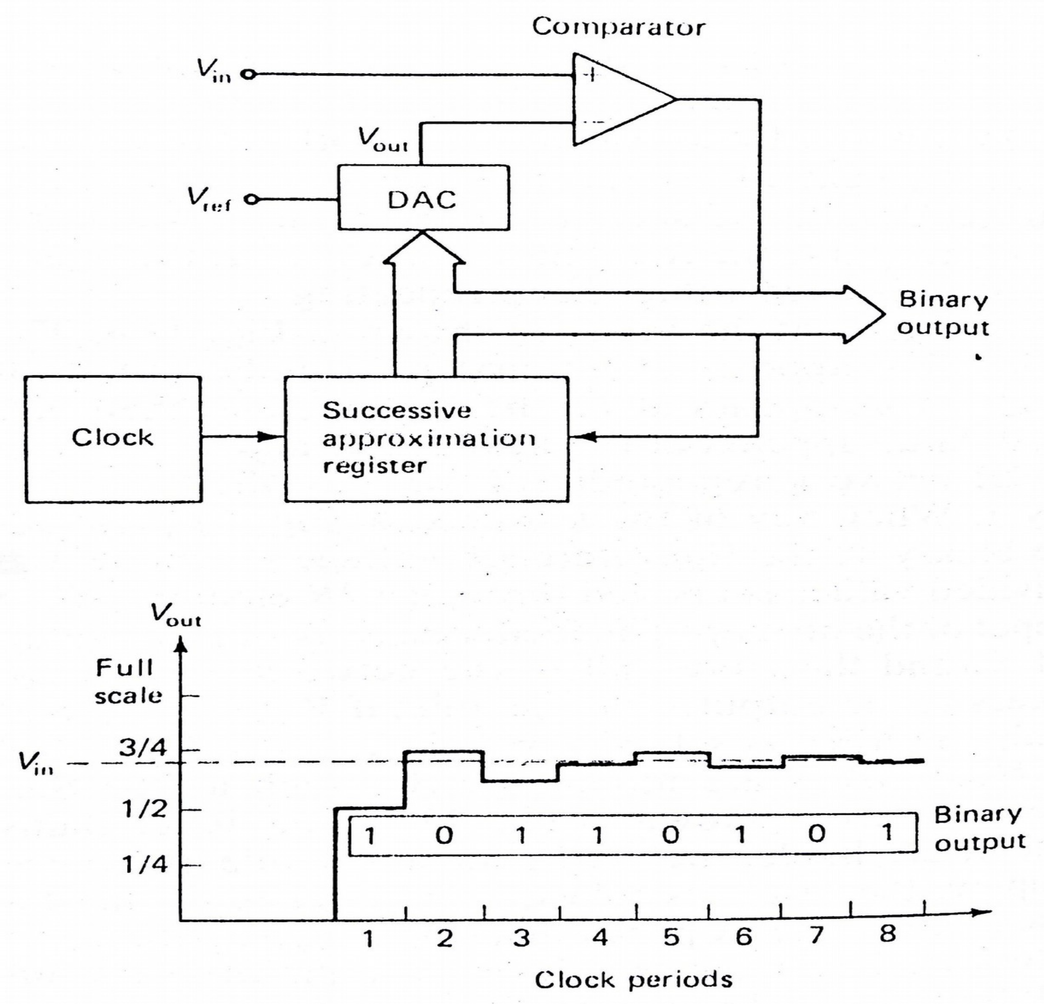
Succesive-approximation ADC



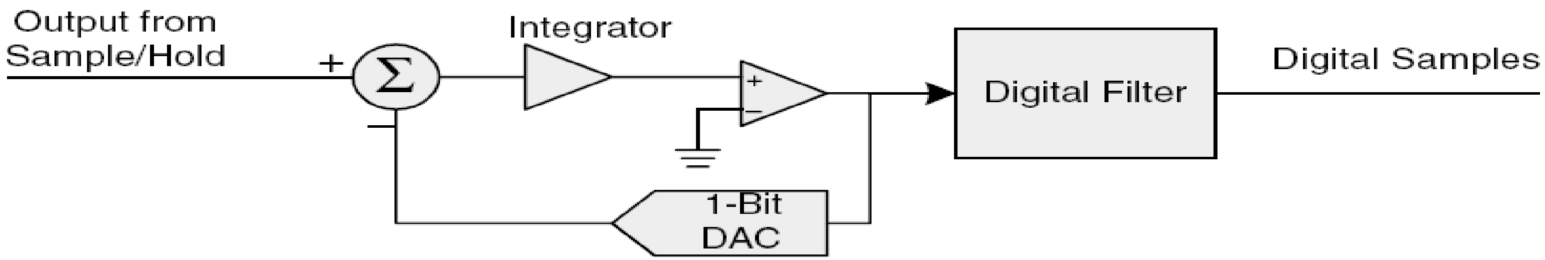
- Uses an internal n-bit DAC
- Conversion logic is a simple n-bit counter
- n-bit ADC requires n cycles to perform a conversion

  in worst case.

Succesive Approximation Conversion

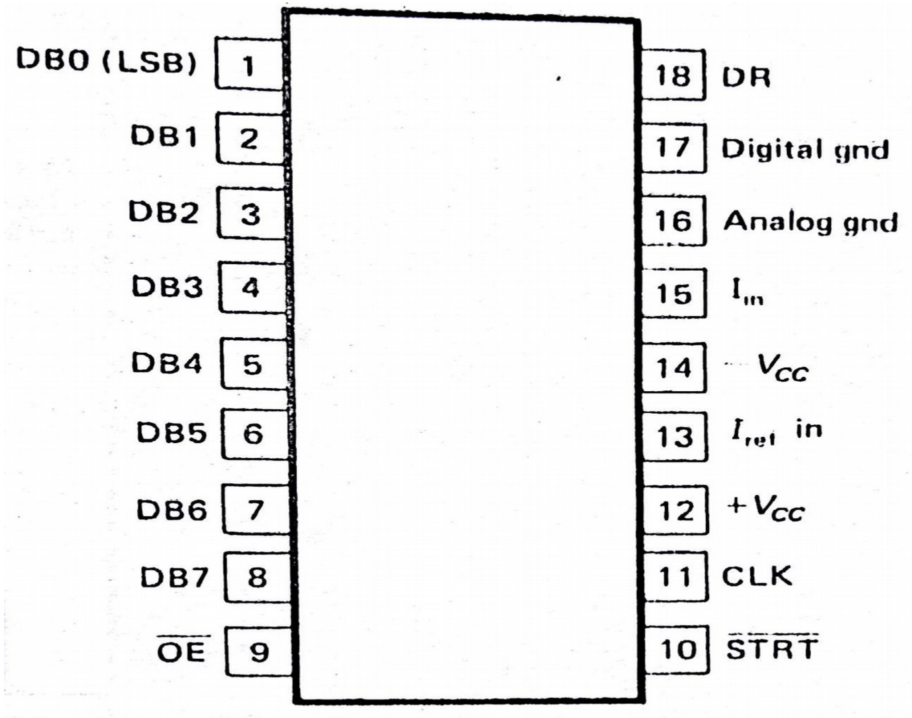


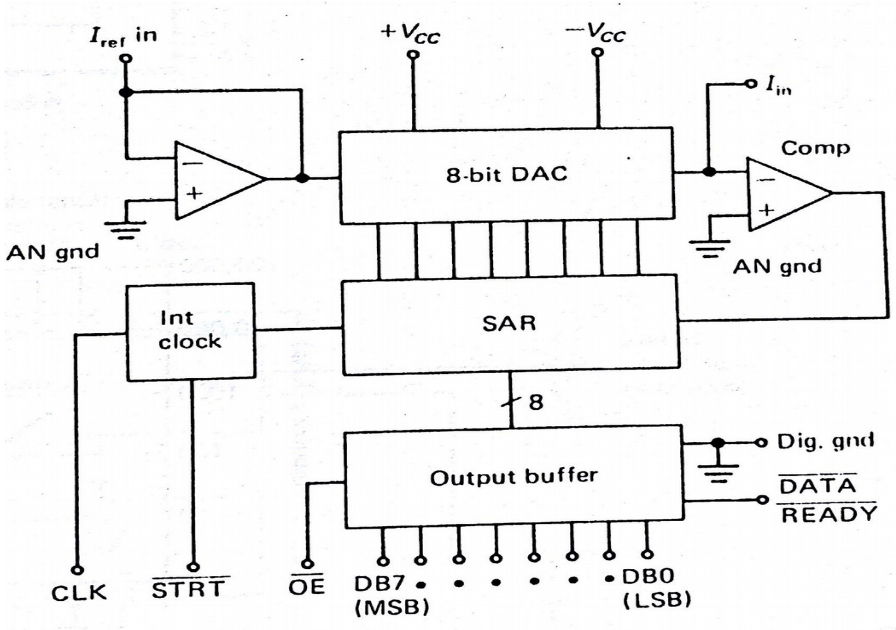
Delta-sigma ADC



- Requires 1-bit DAC: less susceptible to noise
- Requires high sampling rate, suitable for audio applications
- It has digital filter, so no need for expensive low-pass filters at input
- Resolution can be very high.

NE5034 ADC


DB0 (LSB) 1
DB1 2
DB2 3
DB3 4
DB4 5
DB5 6
DB6 7
DB7 8
OE 9
18 DR
17 Digital gnd
16 Analog gnd
15 I_{in}
14 $-V_{CC}$
13 I_{ref} in
12 $+V_{CC}$
11 CLK
10 STRT


I_{ref} in
$+V_{CC}$
$-V_{CC}$
I_{in}
Comp
8-bit DAC
AN gnd
AN gnd
Int clock
SAR
8
Output buffer
Dig. gnd
DATA READY
CLK
STRT
OE
DB7 (MSB)
DB0 (LSB)