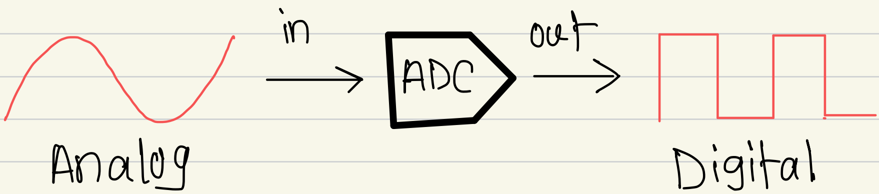
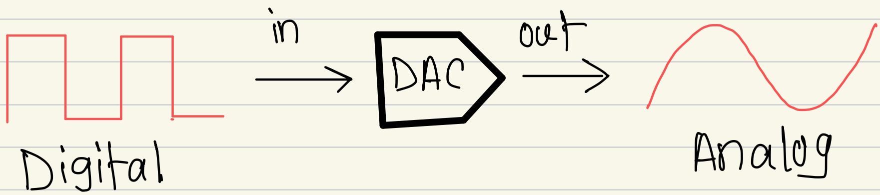
(ADC & DAC)

ADC → Analog to Digital Conversion
DAC → Digital to Analog Conversion





Analog means data could take any real value at each instant of time. It is continuous in time and amplitude. All physical world's signals informations are analog (Temp, pressure, sound ...)

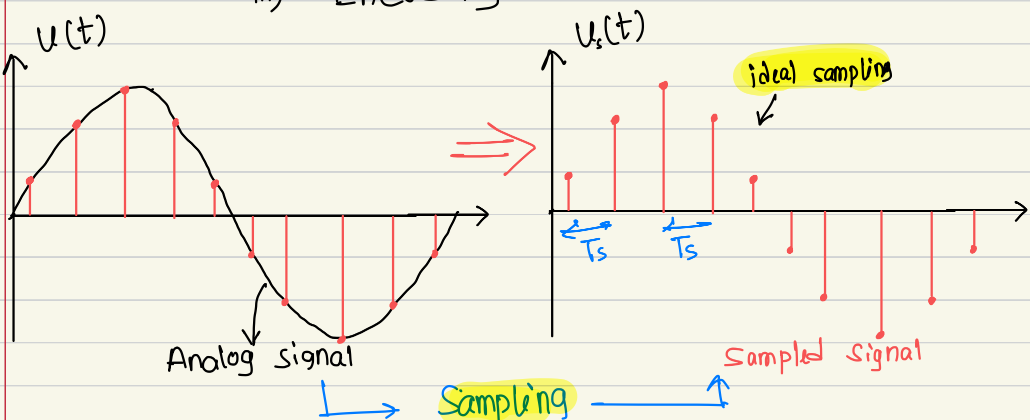
Digital data could take only two values (high or low). It means binary bit of strings. In order to store / process we use digital data in our computers and microprocessors.

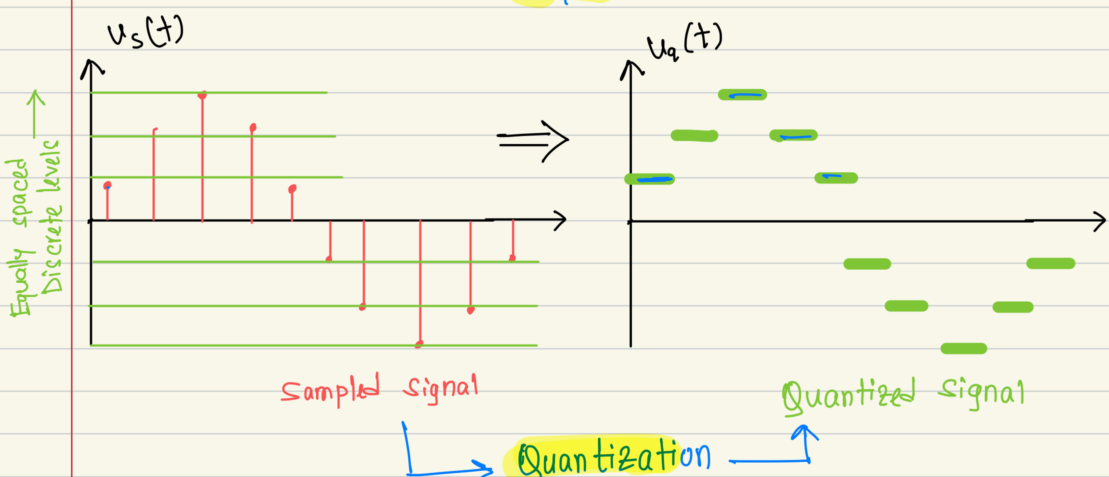
Environment → Transducer → Computer → Speaker/Monitor

(Real world Analog signal) (Analog i/p → Electrical o/p) ADC (Digital processing) DAC (Analog o/p)

A/D conversion process

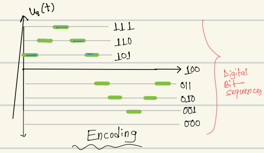
↳ It involves 3 basic steps
- i) Sampling
- ii) Quantization
- iii) Encoding



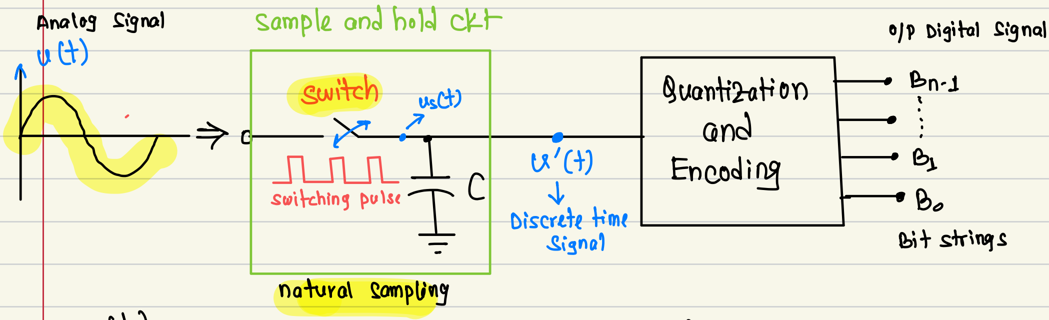


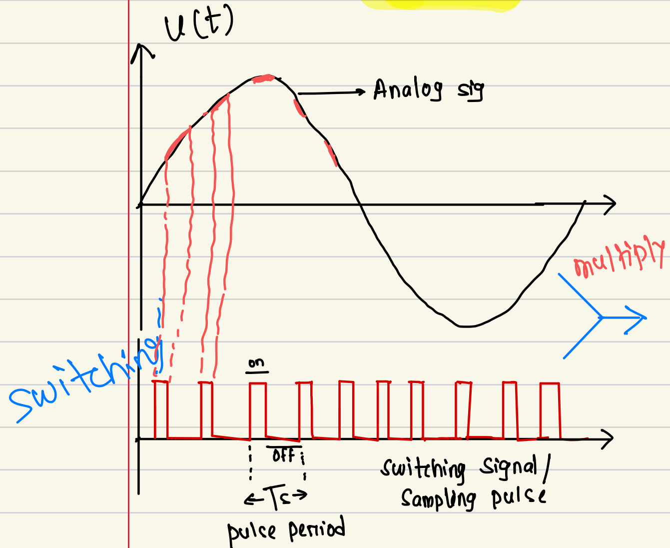
Quantized Signal $u_q(t)$ ⟹ Assigned to corresponding Binary values $\{u_k\}$ (Digital sig)

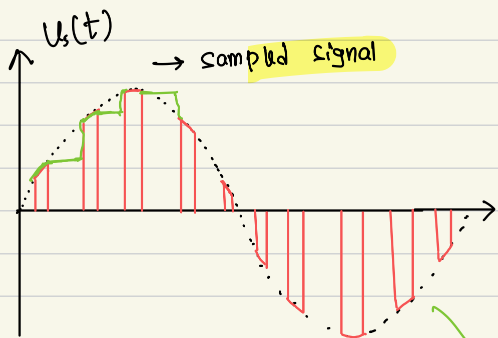
└→ Encoding →↑

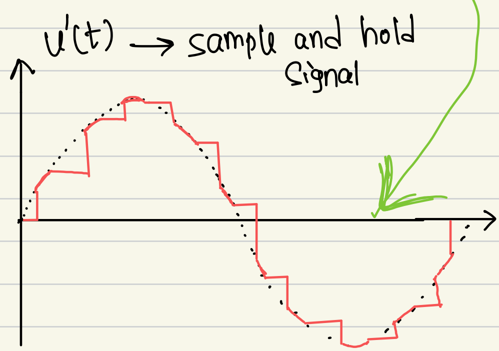


Practical implementation of ADC









This hold operation is done by using capacitor.

Quantization

↳ It is a process by which we assign sampled and hold signal data to some fixed preassigned values / levels.

→ for n bit quantization
num. of levels, $L = 2^n$
gaps btwn two levels → Resolution.

step size | → Resolution, $\Delta = \dfrac{V_{max} - V_{min}}{2^n}$

V_{max} → max value of Analog signal
V_{min} → min " " " "

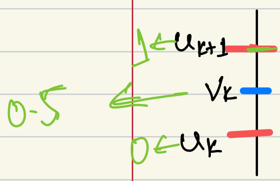
$n\uparrow, L\uparrow, \Delta\downarrow$ → quantization error ↓

2 types

- i) Mid-rise type quantization
- ii) Mid-tread type quantization.

Mid-rise type

→ if i/p sample is in btwn U_K and U_{K+1}



Quantization o/p will be, $V_K = \dfrac{U_K + U_{K+1}}{2}$

U_K, U_{K+1} → pre assigned values/ Levels

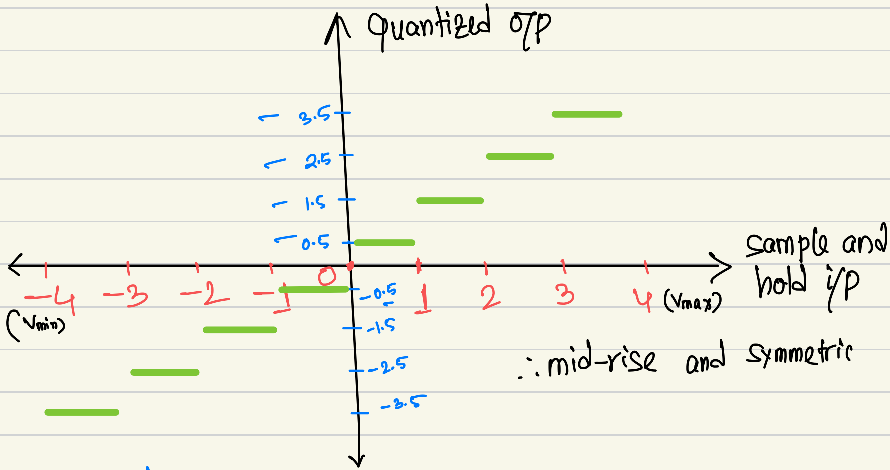
→ rounding

→ $-\Delta/2 \le$ error $\le \Delta/2$

→ Symmetric

Let, $V_{max} = 4$, $V_{min} = -4$, $n = 3$, $2^n = 8$ lvls

$$\Delta = \frac{V_{max} - V_{min}}{2^n} = \frac{4-(-4)}{8} = 1$$



∴ mid-rise and symmetric

Encoding

We can choose binary values for each quantized levels

-4 to 4 $\Delta = 1$

Sampled i/P (U_s)	Quantized Signal (U_q)	Digital Binary o/p {U_e} (Encoding)
3 to 4	3.5	111
2 to 3	2.5	110
1 to 2	1.5	101
0 to 1	0.5	100
−1 to 0	−0.5	011
−2 to −1	−1.5	010
−3 to −2	−2.5	001
−4 to −3	−3.5	000

Digital Signal

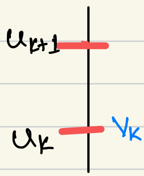
Practice

$V_{min} = 0V,\ V_{max} = 10V,\ n = 3,\ L = 2^n = 8$

$$\Delta = \frac{V_{max} - V_{min}}{L} = \frac{10-0}{8} = 1.25$$

Sampled i/P (U_s)	Quantized Signal (U_q)	Digital Binary o/p {U_e} (Encoding)
8.75-10	9.375	111
7.5-8.75	8.125	110
6.25-7.5	6.875	101
5-6.25	5.625	100
3.75-5	4.375	011
2.5-3.75	3.125	010
1.25-2.5	1.875	001
0-1.25	0.625	000

Mid-tread type



→ if i/p sample is in btwn u_k and u_{k+1}

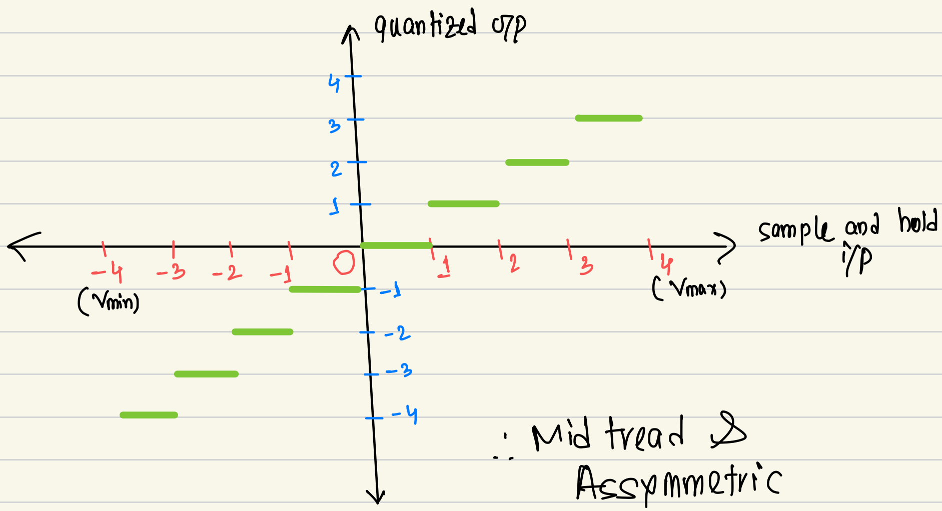
Quantization o/p will be, $V_k = u_k$

u_k, u_{k+1} → pre assigned values / Levels

- → Truncation
- → $0 < \text{error} < \Delta$
- → Assymetric

Let, $V_{max} = 4$, $V_{min} = 4$, $n = 3$, $2^n = 8$ lvls

$$\Delta = \frac{V_{max} - V_{min}}{2^n} = \frac{4-(-4)}{8} = 1$$



∴ Mid tread & Assymmetric

Encoding

Sampled i/P (U_c)	Quantized Signal (U_q)	Digital Binary o/p (U_e)
3 to 4	3	111
2 to 3	2	110
1 to 2	1	101
0 to 1	0	100
−1 to 0	−1	011
−2 to −1	−2	010
−3 to −2	−3	001
−4 to −3	−4	000

Practice

$V_{min} = 0V, \; V_{max} = 10V, \; n = 3$

Encoding

Sampled i/P (U_c)	Quantized Signal (U_q)	Digital Binary o/p (U_e)

Practice

For the following sequences
$\{1.2, -0.2, -0.5, 0.4, 0.89, 1.3\}$
quantize it using a uniform midrise type quantizer and write the quantized and encoded sequence.
Quantizer range is $(-1.5, 1.5)$ with 4 levels

Sol^n:

$\{U_s\}$	$\{U_q\}$	$\{U_e\}$

$\{U_s\} = \{1.2, -0.2, -0.5, 0.4, 0.89, 1.3\}$

$\{U_q\} = \{ \quad \}$

$\{U_e\} = \{ \quad \}$