Iqraq’s Note

Fundamental Signal Processing

What is Signal Processing (SP)

- Field of science involving manipulation of signals to get the desired shaping
- Change from time domain to frequency and vice versa
- Smoothening, separating noise, filtering, extracting

- - Nature signal exist in continuous manner
  - $t_1, t_2 = -\infty , \infty$

Flow of (SP)

- Need to convert to digital for computer to read

Fig : Basic Elements of Signal Processing System

AD conversion

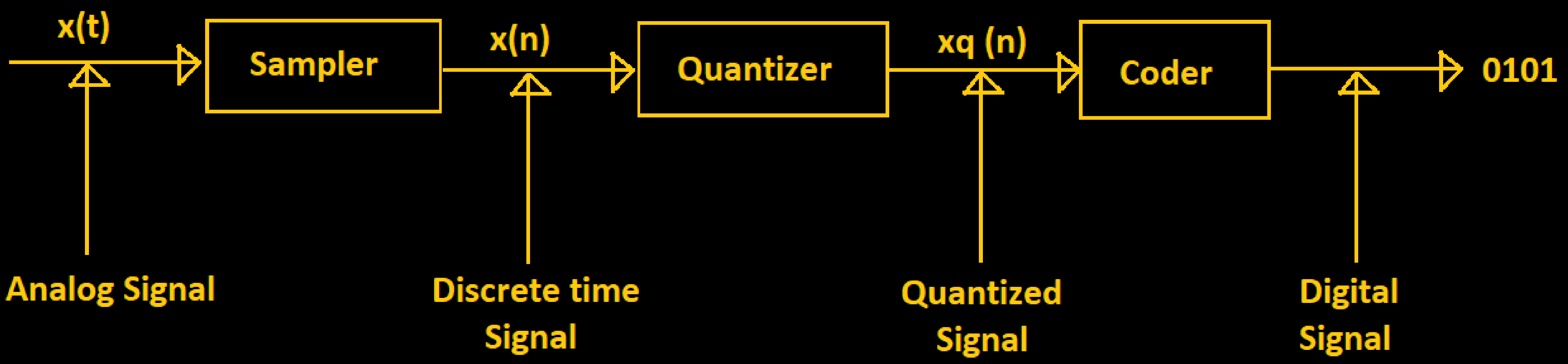
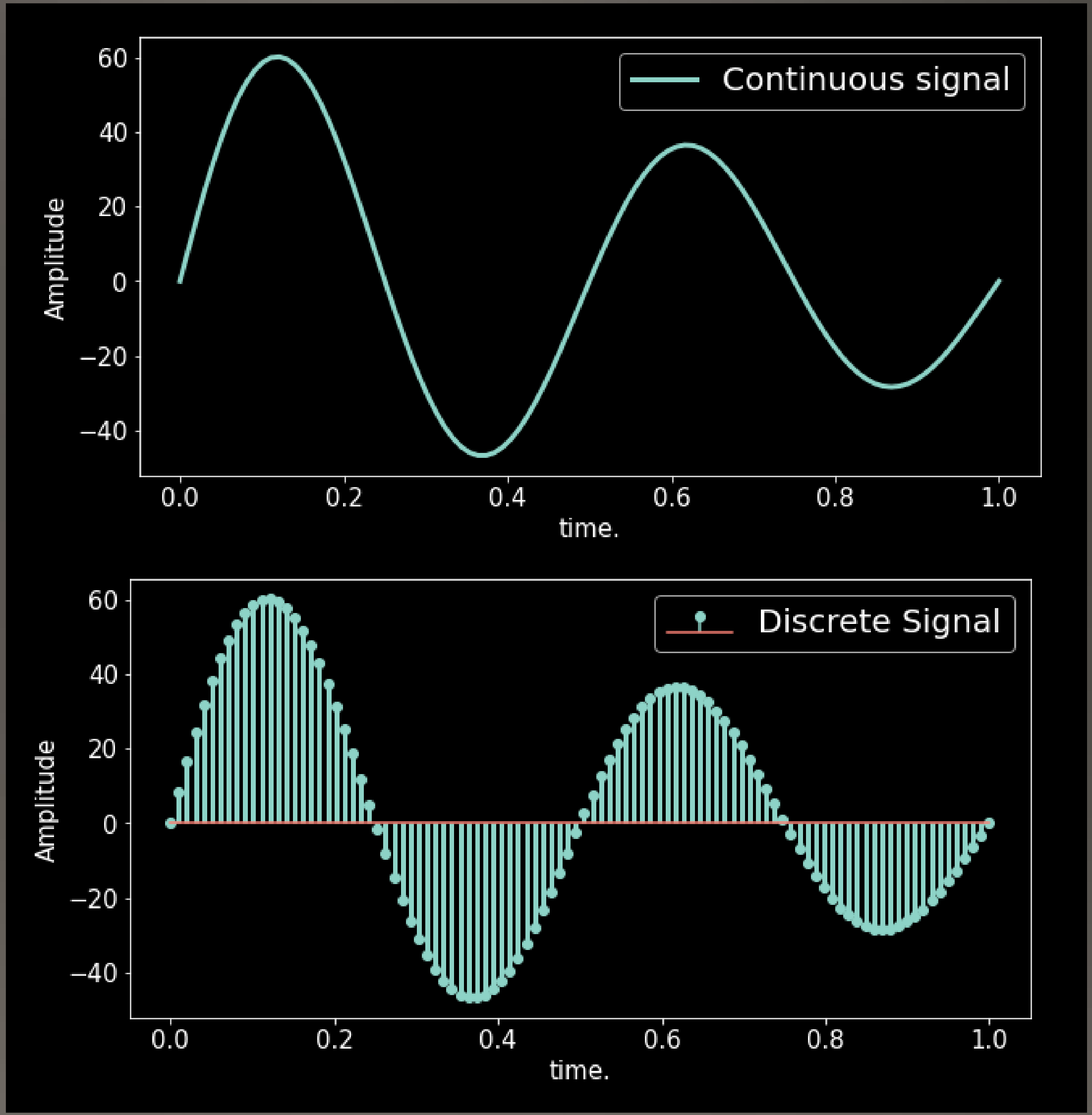


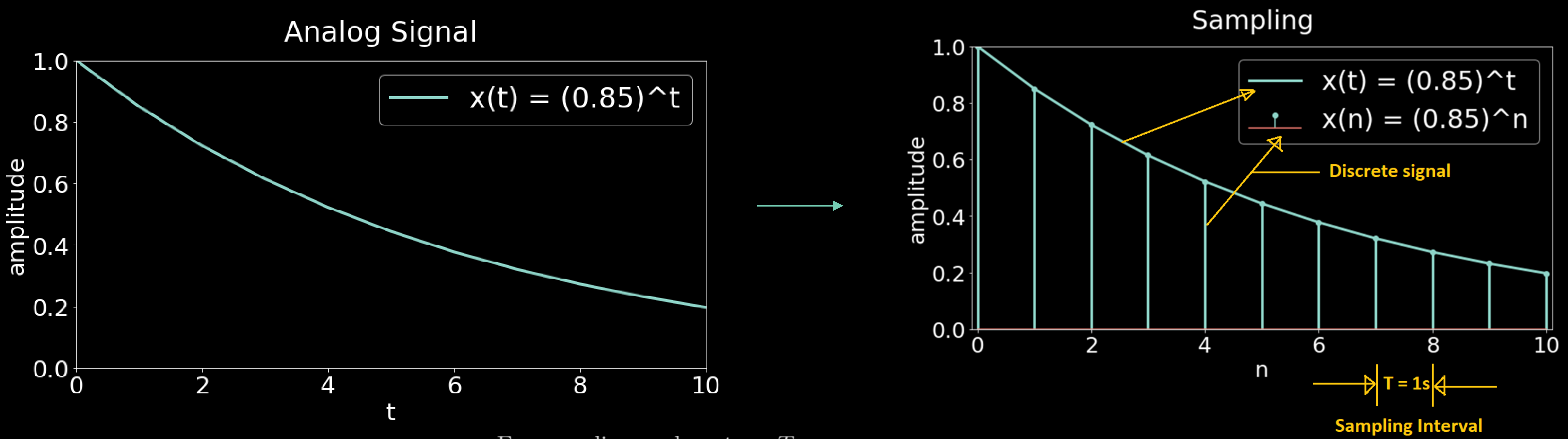
Fig : Elements of Analog to Digital Convertor

What is sampling?

- the reduction of a continuous-time signal to a discrete-time signal
- To know the value at instantaneous point
- Need to define sampling interval (T) by setting sampling frequency
- $fs = 1Hz$
- $T = \frac{1}{fs}$
- $T = 1s$



Example



For sampling replace $t = nT$.

Thus,

$x(nT) = (0.85)^{nT}$

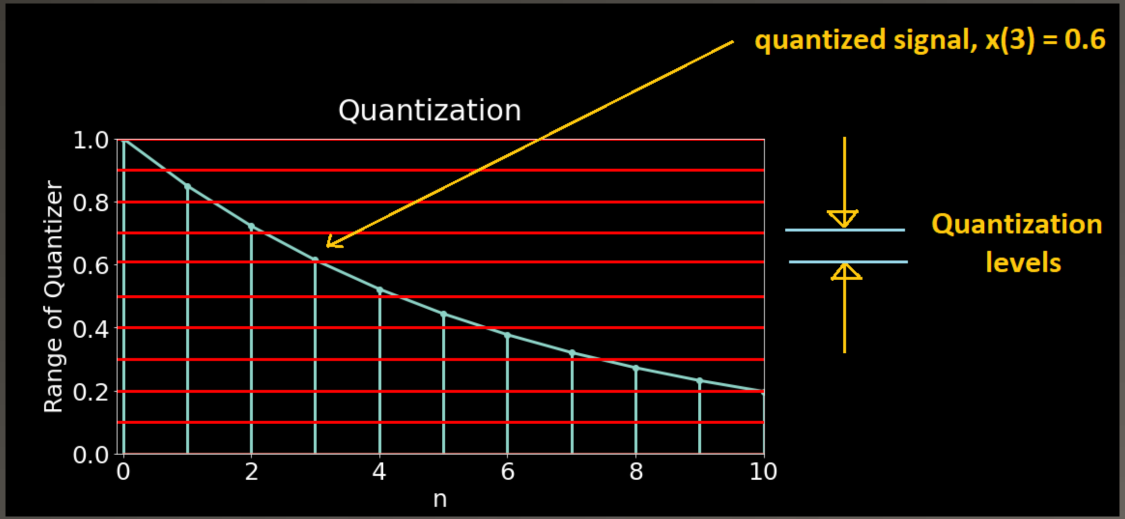
Since $T = 1s$, therefore,

$x(n) = (0.85)^n$

$x(n)$ is the discrete time signal with sampling interval of $1s$.

What is Quantization

- Process of converting amplitude of discrete signal into digital signal by expressing each sample value as a finite
- Accuracy = how many discrete levels are allowed to represent the magnitude of signal.



Discrete time (n)	Discrete signal $(0.85)^n$	Quantized signal
0	1	1
1	0.85	0.9
2	0.7224999999999999	0.7
3	0.6041249999999999	0.6
4	0.5220062499999999	0.5
5	0.44370531249999995	0.4
6	0.37714951562499993	0.4
7	0.3205770882812499	0.3
8	0.27249052503906246	0.3
9	0.23161694628320306	0.2
10	0.19687440434072260	0.2

Quantized signal after rounding discrete time signal

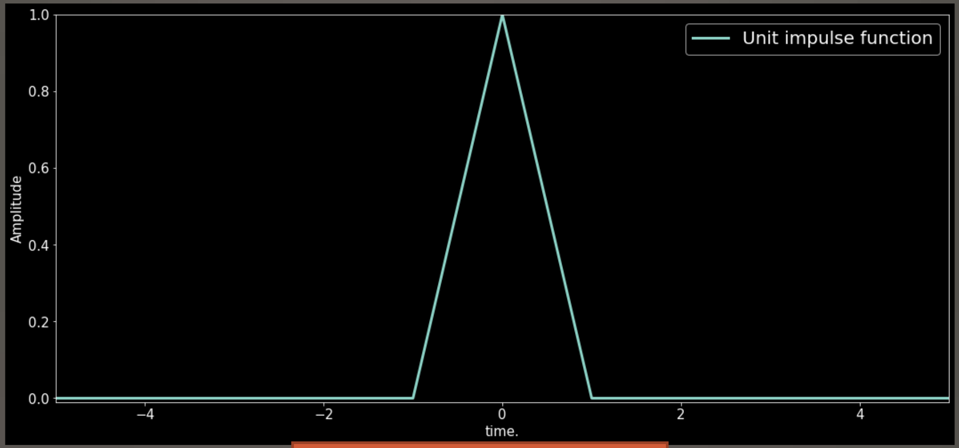
Coding

- Higher bit number will have higher quantized level –reading are more accurate
- Example of 4 bit (b0 – b3)

b_3	b_2	b_1	b_0	**Quantized Levels**
0	0	0	0	0.0
0	0	0	1	0.1
0	0	1	0	0.2
0	0	1	1	0.3
0	1	0	0	0.4
0	1	0	1	0.5
0	1	1	0	0.6
0	1	1	1	0.7
1	0	0	0	0.8
1	0	0	1	0.9
1	0	1	0	1.0

Fundamentals for Positive continuous time signal (t>o) and discrete time signal

- Unit impulse signal
- $S(t) = 1 \; for \; t = 0$
  and
- $S(t) = 0 \; for \; t \; \neq \; 0$



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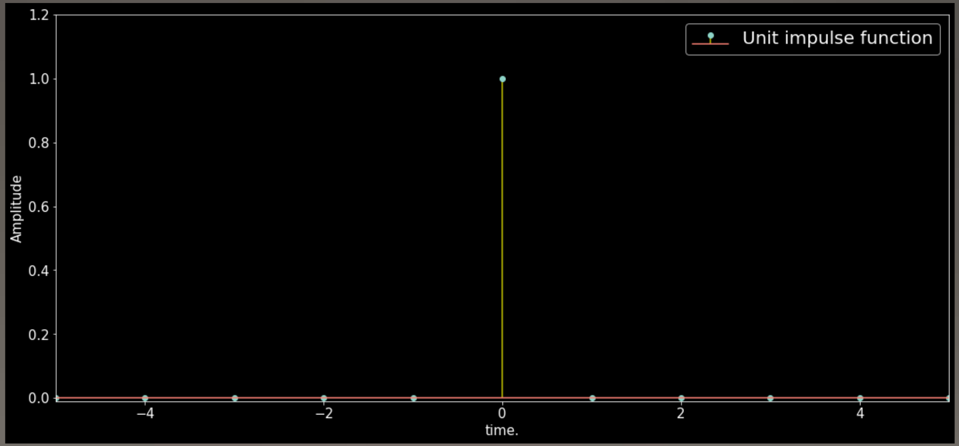
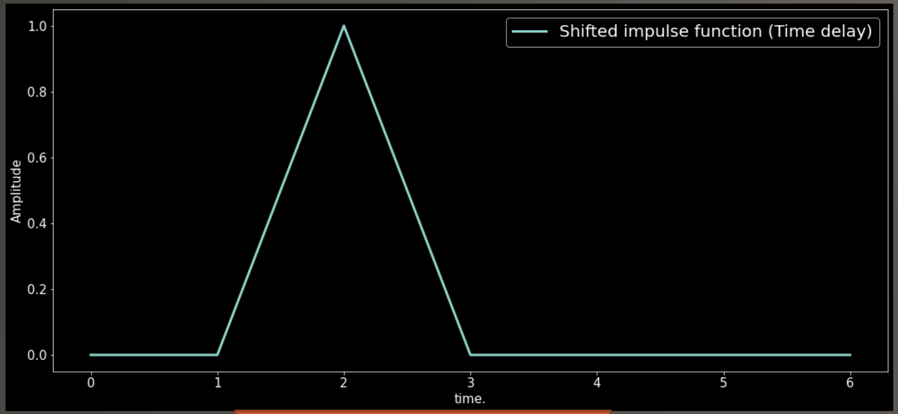


Discrete

1. Time Delay
    1. Move signal towards positive time axis
    2. $S(t-2)=1$



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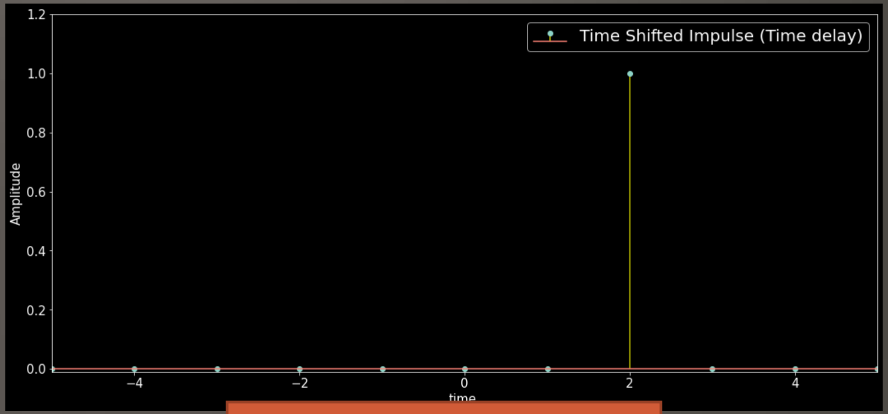
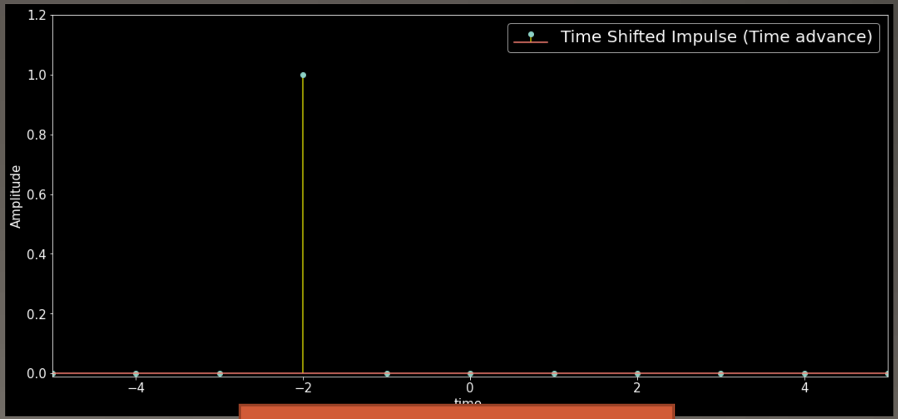


Discrete

2. Time advance
    1. Move signal towards negative time axis
    2. $S(t-2)=1$

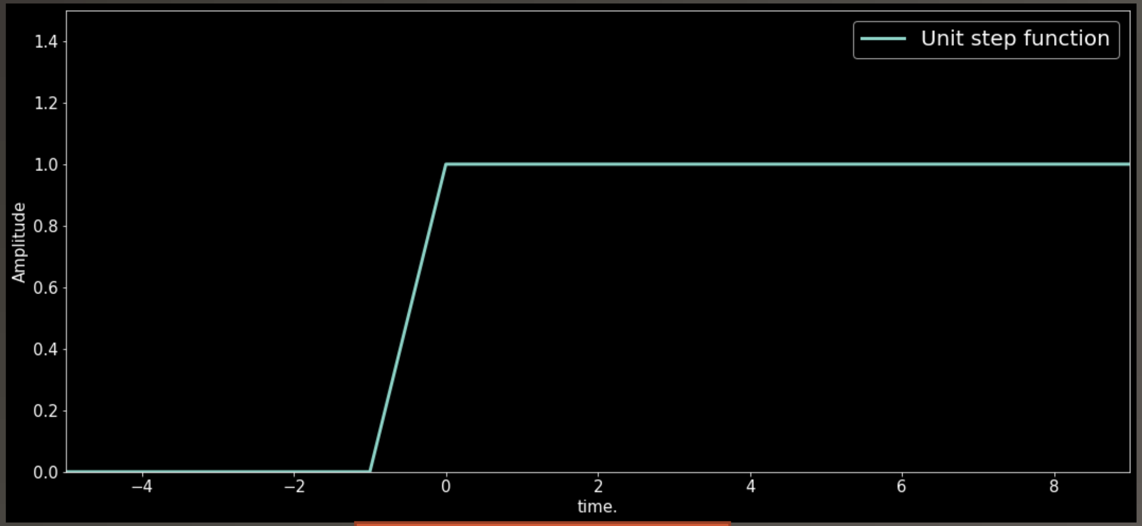
Continuous



Discrete

3. Unit Step Signal

1. Function having magnitude of 1 at time equal to and greater than zero
2. $\mathrm{u}(t) = 1\ for\ t\ \geq 0\ \ \&\ \ \mathrm{u}(t) = 0\ for\ t < \ 0$



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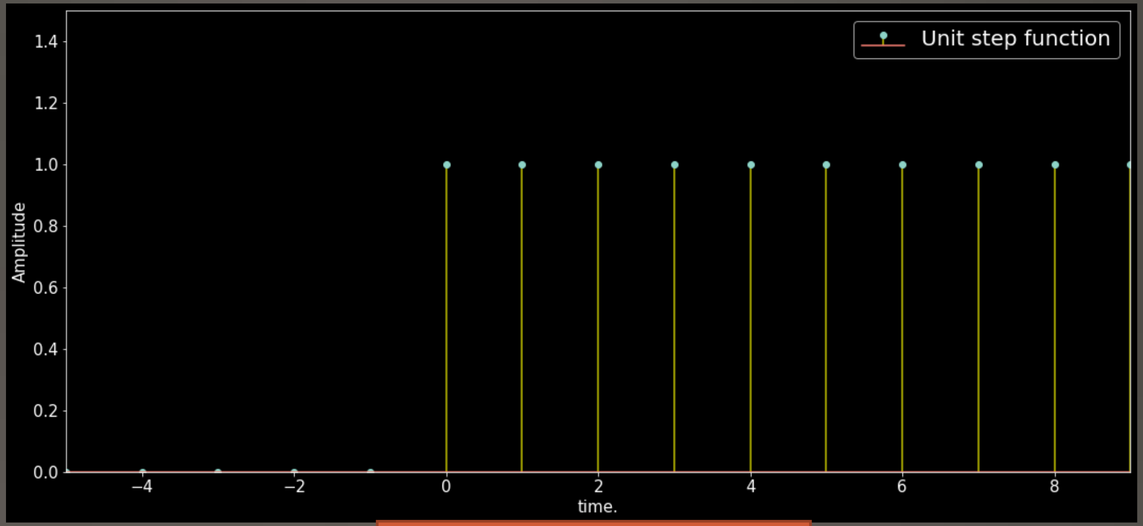
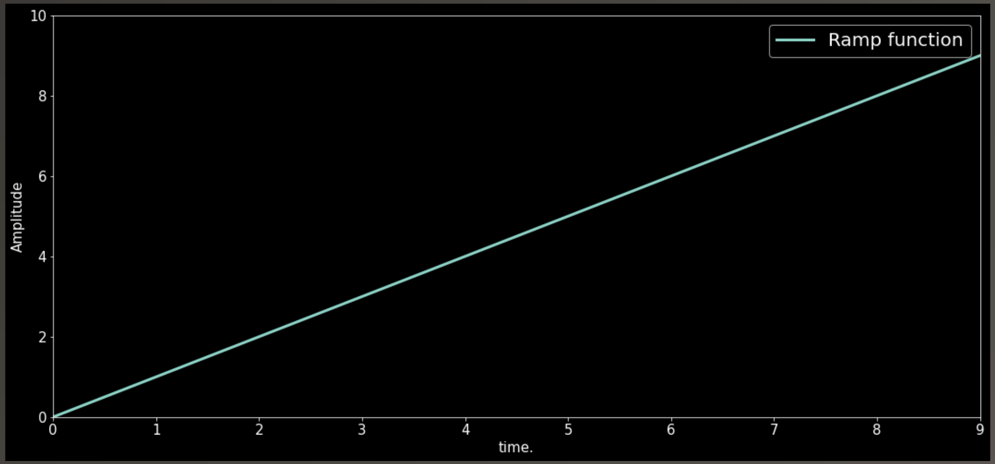


Discrete

4. Unit Ramp Signal

- Function having a magnitude of t at t≥o

1. $x(t) = 1\ for\ t\ \geq 0\ \ \&\ \ x(t) = 0\ for\ t < \ 0$



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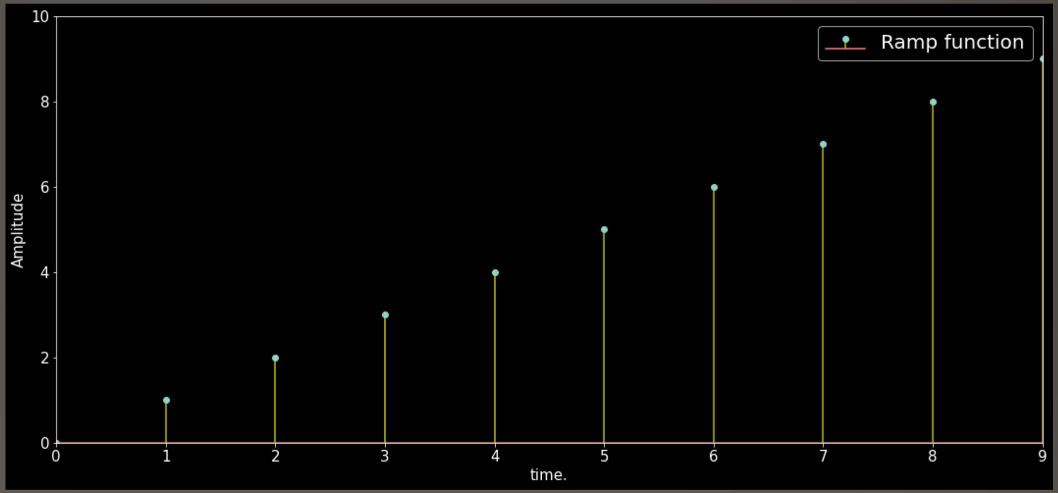
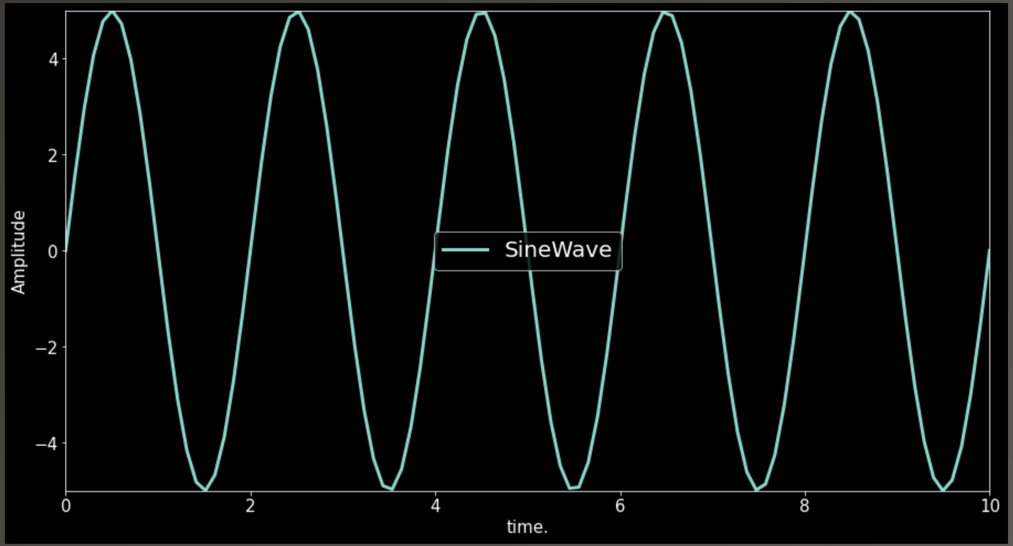


Discrete

5. Sinusoidal Signal

- Oscillations that repeat over a fixed interval of time period of the signal

1. $x(t) = A\sin(2\pi f t)$
2. A – Amplitude , f = Frequency



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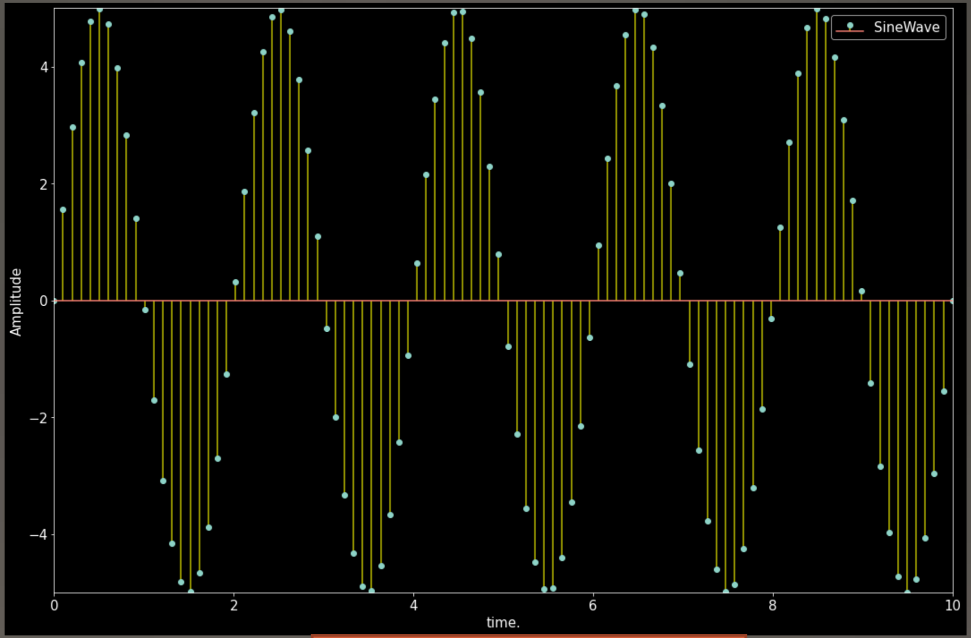


Discrete

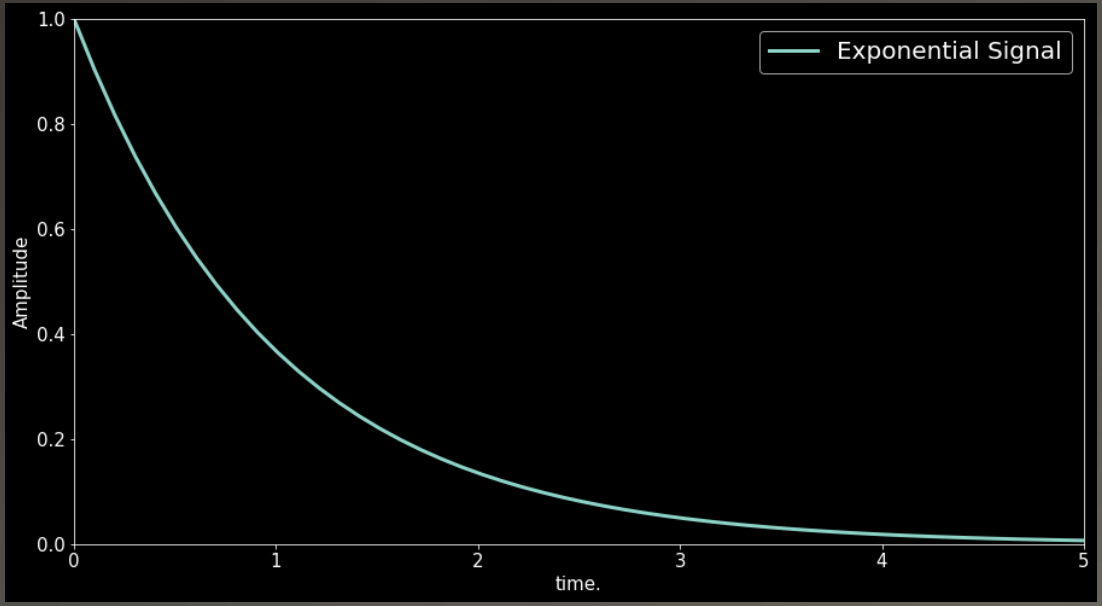
5. Unit Exponential Signal

1. 1 at t(0) and exponentially decaying for time greater than zero, for t>0

2. $x(t) = 1 \; for \; t = 0$

and

$$x(t) = e^{-t} \; for \; t > 0$$



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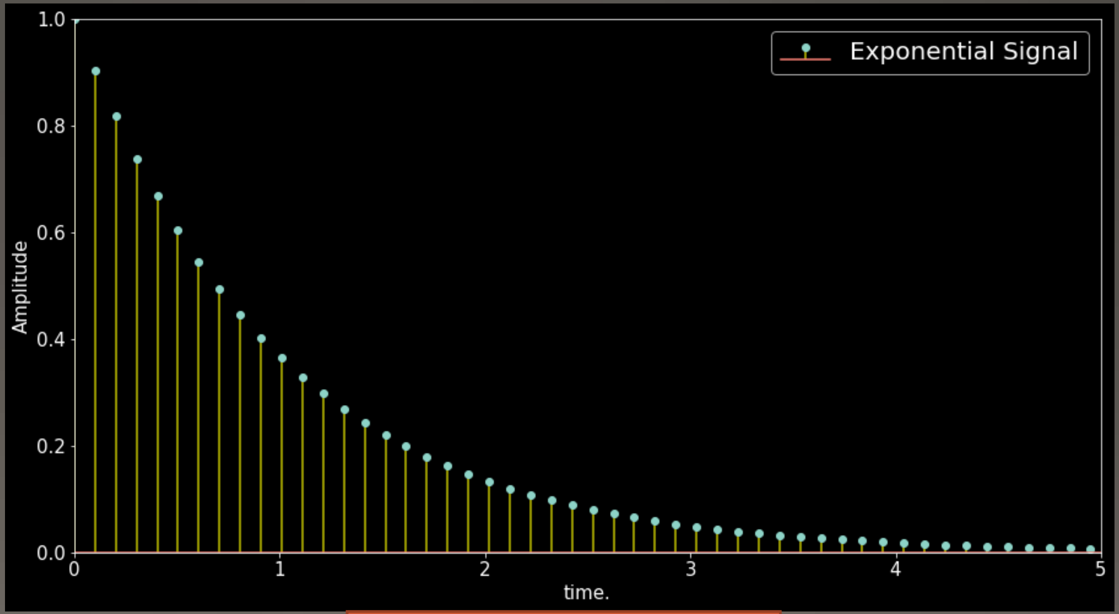


Discrete

Sampling and reconstruction

- Convert continuous time signal x(t) to disctrete x(n) by replacing t with nT.
- $\mathrm{x}(n) = x(nT)$
- Where x(n) is the discrete time signal obtained by taking samples of the continuous time signal x(t) every T seconds. The T between successive samples is called the sampling period.

- $T = \frac{1}{fs}$
- Where fs is called sampling rate or the sampling frequency (Hz)

Nyquist sampling theorem

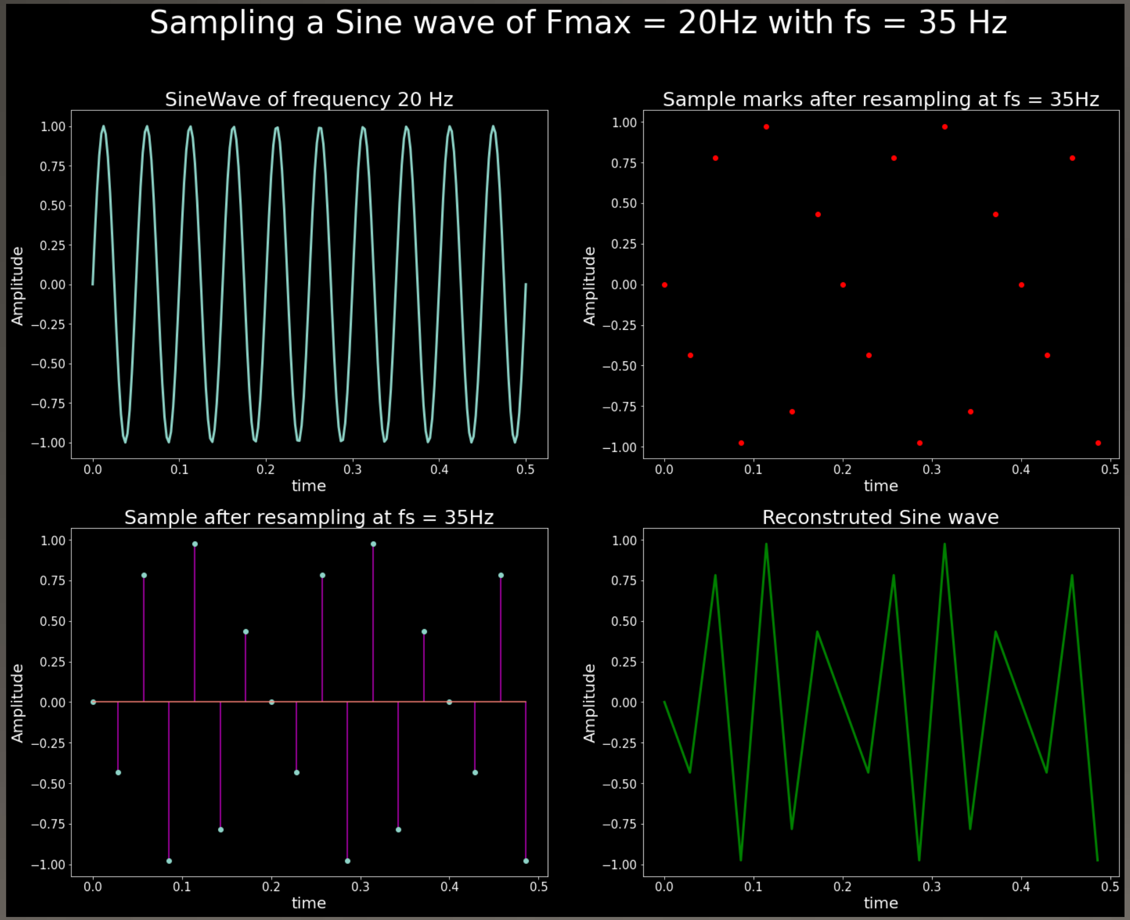
- States that the sampling frequency should be greater or equal than twice the maximum frequency of the signal

If fmax is the maximum frequency of the signal than

$F_s \geq 2F_{max}$

This theorem is important if we want to reconstruct the signal after sampling.

Lower sample rate – low accuracy of reconstructed signal



Higher sampling rate = higher accuracy of reconstructed signal