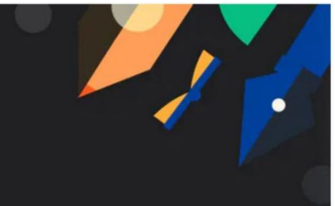
Basics of Signal - Part I

Comprehensive Course on Signal System



Vishal Soni • Lesson 1 • Dec 1, 2021

SYLLABUS

→ Signals

→ System

→ Continuous Time Fourier Series (CTFS)

→ Continuous Time Fourier Transform (CTFT)

→ Sampling

→ Laplace Transform → Z. Transform

→ Discrete Time Fourier Transform (D.T.F.T.)

→ Discrete Fourier Transform (D.F.T.)

→ Fast Fourier Transform (F.F.T.) → ECE (GATE)

→ Discrete Cosine Transform (EE (GATE))

Marks

- GATE → 6-8 Marks
- ESE
  - → 20-30 Mark (prelims)
  - → 50 Mark (Mains)

Resources →

1. Class Notes
2. D.P.P.

parallel ←
- 3. Kanodiya →
- 4. Openheim → "G. K. Publication (unsolved)."

5. PYQ → periodically
   - EC, EE, IN — GATE 2023
   - EC, EE — (ESE) 2023

6. Bits-Bytes

Books →
1. T. K. Rawat
2. Openheim

"BASICS of Signals"

Signal : Signal is mathematical Representation of a physical phenomenon, which contains some information.

Ex: Physical phenomenon: AC voltage

Mathematical Rep: $x(t) = A\cos\omega_0 t$ → signal.

(A → Amplitude, ω_0 → frequency)

Signal: → Signal is dependent variable which depends on one or more independent variable.

1. $x(t)$ → D.V. $x(t)$
   → I.D.V. t → continuous Time

$x(t)$: Continuous Time Signal

2) $x[n]$ → D.V. $x(n)$

→ IDV {n} → Discrete Time

→ Discrete Time Signal.

3) $X(\omega)$ or $X(f)$ → D.V. $X(\omega)/X(f)$

→ IDV: ω or f

↳ Continuous Frequency

→ Continuous Frequency signal

$\omega = 2\pi f$

ω = rad/sec

f = Hz

4) $X(n\omega_0)$ or $X(nf_0)$ → D.V.: $X(n\omega_0)/X(nf_0)$

→ IDV: $n\omega_0$ or nf_0

↳ Discrete frequency

→ Discrete Frequency Signal.

Q.

1. C.T.S. $x(t)$ ⟷ (C.T.F.T.) C.F.S. $X(\omega)$

2. C.T.S. $x(t)$ ⟷ (C.T.F.S.) D.F.S. $X(n\omega_0)$

3. DTS $x(n)$ ⟷ (D.T.F.T.) C.F.S. $X(\omega)$

4. DTS $x(n)$ ⟷ (D.T.F.S.) DFS $X(n\omega_0)$.

CLASSIFICATION of SIGNAL

1) C.T.S. and D.T.S.
2) EVEN and ODD
3) Evenconjugate and ODDconjugate
4) Periodic, Nonperiodic
5) orthogonal, Nonorthogonal
6) E, P, NENP signal
7) Causal, Noncausal, Anticausal
8) Bounded, unbounded
9) Absolutely Integrable
10) LSS, RSS, BSS.

Continuous and Discrete Time Signal

Continuous Time signals:

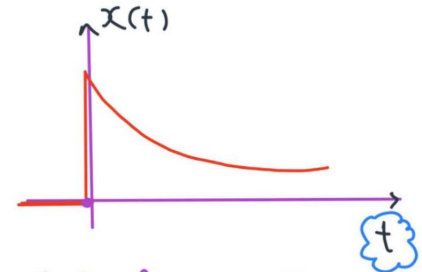
finite

LHL = RHL = f(a)

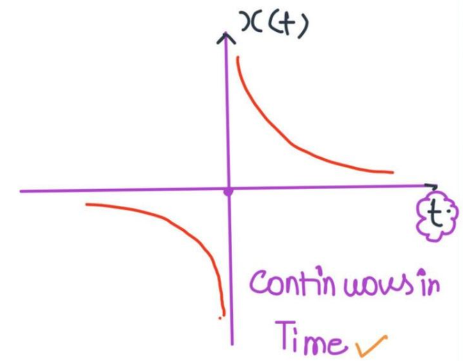
Continuous Signal
- → Continuous in Amplitude
- → Continuous in Time.

(t) ✓

x(t) vs t.

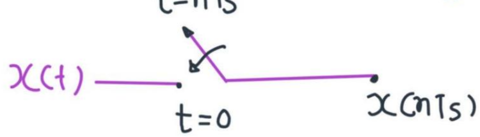


Continuous in Time ✓



Discrete Time Signal :

D.T.S. is obtained from C.T.S. by a process called as UNIFORM SAMPLING.

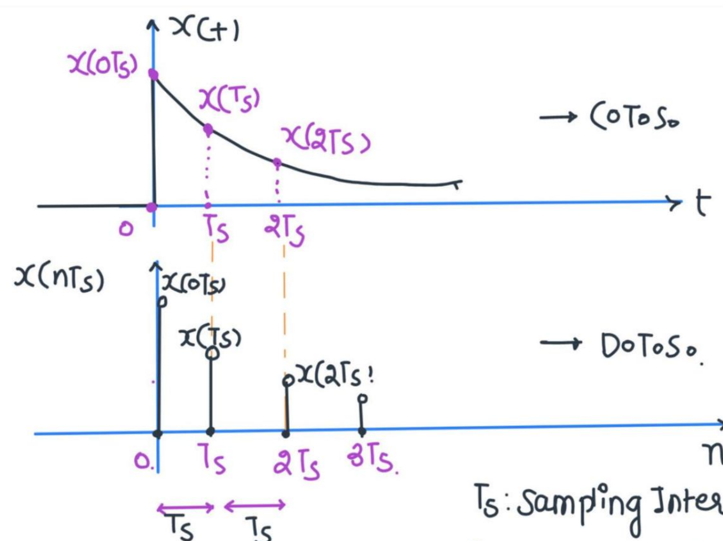


t=0

t=Ts

t=2Ts

t=3Ts



T_s: Sampling Interval

$f_s = 1/T_s$ = Sampling frequency.

Mathematical Conversion:

Given: $x(t) = f(t) : a \leq t \leq b$

S.1 Identify f_s or T_s

S.2 $t = nT_s$

$x(nT_s) = f(nT_s) : a \leq nT_s \leq b$

$\downarrow$

$x(n) = f(nT_s) : \frac{a}{T_s} \leq n \leq \frac{b}{T_s}$

Q. $x(t) = \sin(200\pi t)$ Calculate D.T.S. If $f_s = 10\,Hz$

S.1 $T_s = \frac{1}{f_s} = 0.1\,sec$

S.2 $x(nT_s) = \sin(200\pi(nT_s))$ ($T_s = 0.1$)

$\downarrow$

$x(n) = \sin(20\pi n)$

Q. $x(t) = \frac{1}{2}e^{-0.5t}$ D.T.S. if $f_s = 10\,Hz$.

S.1 $T_s = \frac{1}{f_s} = 0.1\,sec$

S.2 $x(nT_s) = \frac{1}{2}e^{-0.5nT_s}$ ($T_s = 0.1$)

$\downarrow$ ($-0.05n$)

$x(n) = \frac{1}{2}e^{-0.05n}$

Q. $x(t) = \begin{cases} 1-|t| & : |t| \leq 4 \\ 0 & : \text{else} \end{cases}$ $T_s = 2\,sec$

S.1 → $T_s = 2$

S.2 → $x(nT_s) = \begin{cases} 1-|nT_s| & : |nT_s| \leq 4 \\ 0 & \text{else.} \end{cases}$

$\downarrow$

$x(n) = \begin{cases} 1-|2n| & : |2n| \leq 4 \\ 0 & : \text{else} \end{cases}$

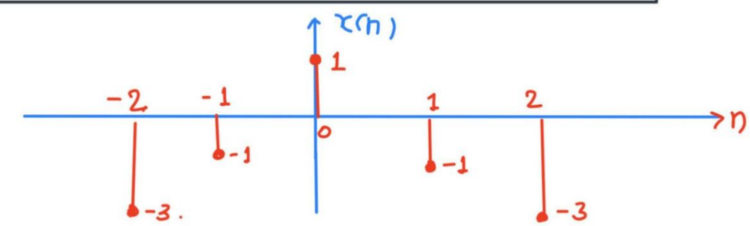
$$x(n) = \begin{cases} 1-2|n| & : 2|n| \leq 4 \\ 0 & : \text{elsew} \end{cases}$$

$$x(n) = \begin{cases} 1-2|n| & : |n| \leq 2 \equiv -2 \leq n \leq 2 \\ 0 & : \text{else} \end{cases}$$

$$x(n) = \begin{cases} 1-2|n| & : n = -2, -1, 0, 1, 2 \\ 0 & : \text{elsewhere} \end{cases}$$

$$x(n) = \{-3, -1, \underset{\uparrow}{1}, -1, -3\}$$

$n=-2 \quad n=-1 \quad n=0 \quad n=1 \quad n=2$



Q.

$$x(t) = \begin{cases} 1 - \frac{|t|}{4} & : |t| \leq 4 \\ 0 & ; \text{elsewhere} \end{cases}$$

$f_s = 0.25\,Hz.$

1) $T_s = 4$

2) $$x(nT_s) = \begin{cases} 1 - \frac{|nT_s|}{4} & : |nT_s| \leq 4 \\ 0 & : \text{else} \end{cases}$$

$$x(n) = \begin{cases} 1-|n| & : |n| \leq 1 \\ 0 & : \text{else} \end{cases} = \begin{cases} 1-|n| & n = -1, 0, 1 \\ 0 & \text{elsewhere} \end{cases}$$

OPERATIONS ON SIGNALS

OPERATIONS on Continuous Time Signal

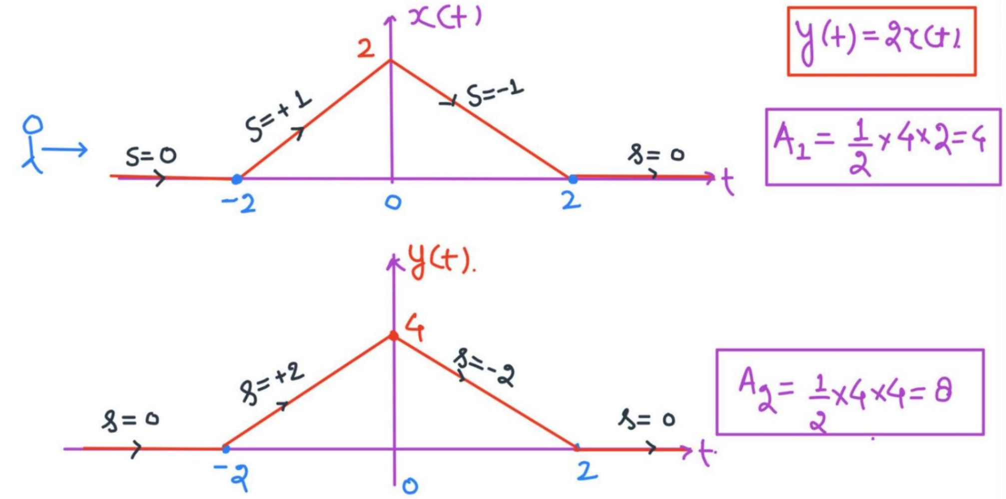
operations on D.V.

1) Amplitude scaling

Given: $x(t)$ vs t

Plot: $A\,x(t)$ vs t

Process → Multiply vertical axis parameter by A

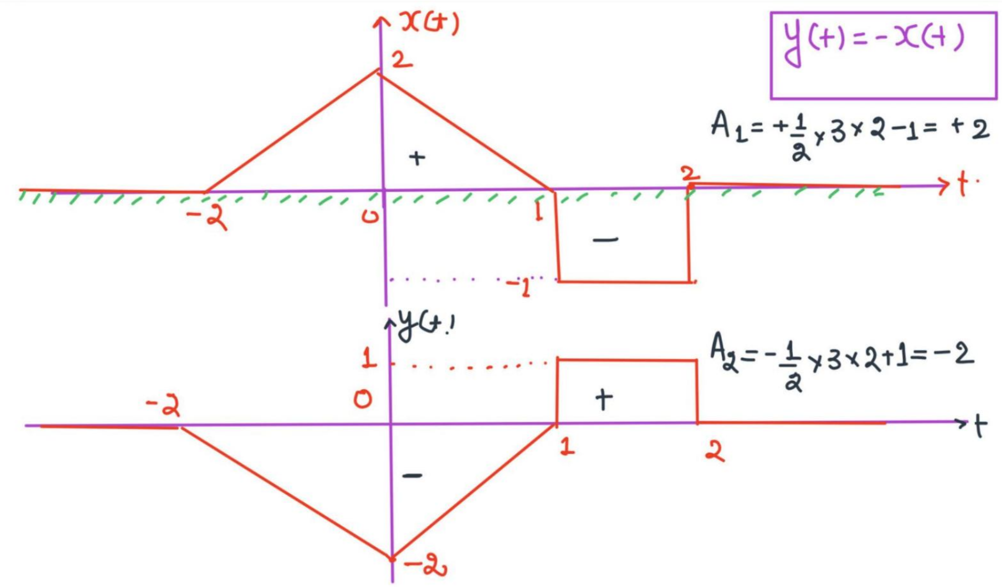


2. Amplitude Reversal:

Given: $x(t)$ vs t

Plot: $-x(t)$ vs t

Procedure: Take mirror image w.r.t. Horizontal axis.



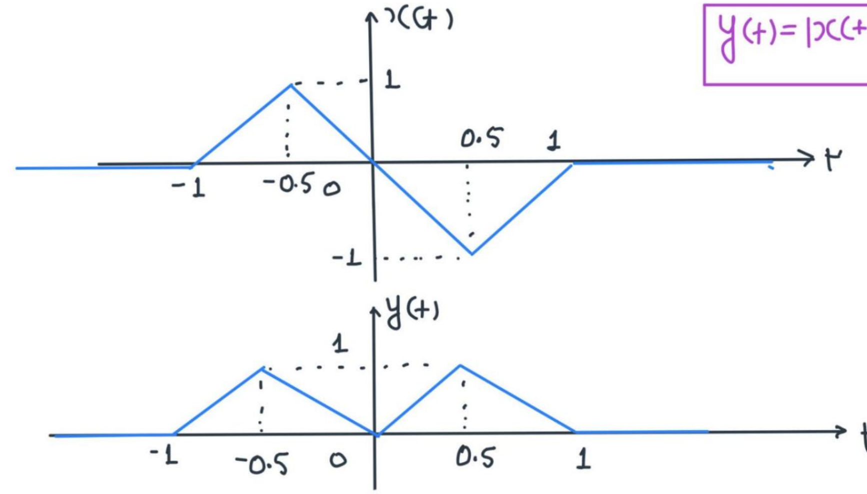
3 Modulus operation:

Given: $x(t)$ vs t

Plot: $|x(t)|$ vs t

Procedure
- above Horizontal axis : keep as it is
- below Horizontal axis : reflect above.

$y(t) = |x(t)|$



4 Addition or Subtraction of dc value:

Given: $x(t)$ vs t

Plot: $x(t) \pm A$ vs t

Procedure:

$x(t) + A \longrightarrow$ shift A unit upward

$x(t) - A \longrightarrow$ shift A unit downward

$y(t) = x(t) + 2$