SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT202 – SIGNALS AND SYSTEMS

II YEAR/ III SEMESTER

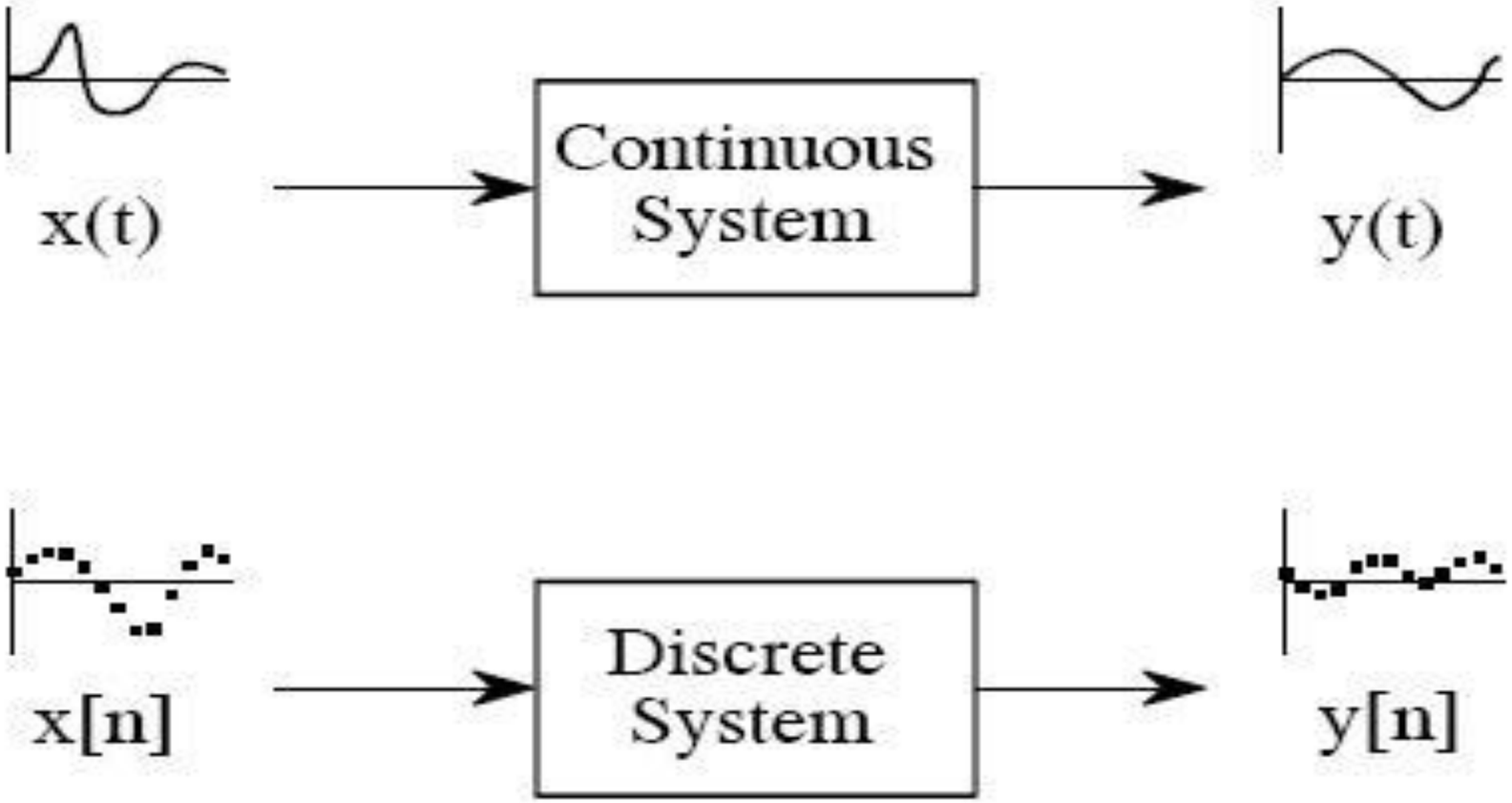
UNIT 1 – CLASSIFICATION OF SIGNALS AND SYSTEMS

TOPIC – Continuous Time Systems and its Classification

SYSTEM

- A System is a set of elements or functional blocks that are connected together to produces an output with response to input signal
- Systems process input signals to produce output signals
- Eg. Audio amplifier, Receiver

CONTINUOUS & DISCRETE SYSTEM



CT & DT SYSTEM

- **Continuous Time System:** It operates on a continuous time signal (input or excitation) produces another continuous time signal (output or response)
- **Response y(t) = T {x(t)}**

- **Discrete Time System:** It operates on a discrete time signal (input or excitation) and produces another discrete time signal (output or response)
- **Response $y(n)$ = N {x (n)}**

CLASSIFICATION OF SYSTEMS

It can be classified into

1. Linear and Non linear Systems
2. Time Invariant & Variant Systems
3. Causal and Non Causal Systems
4. Static and Dynamic Systems
5. Stable and Unstable Systems

CT LINEAR & NON LINEAR SYSTEM

- **Linear System:** A system is said to be linear if it obeys superposition theorem
- Superposition theorem states that the response of a system to a weighted sum of the signals is equal to the corresponding weighted sum of responses to each of the individual input signals
- **Condition for Linearity :**

$$\mathbf{T\,[ax_1(t) + bx_2(t)] = ay_1(t) + by_2(t)]}$$

- **Non Linear system:** A system is said to be Non linear if it does not obeys superposition theorem

$$\mathbf{T\,[ax_1(t) + bx_2(t)] \neq ay_1(t) + by_2(t)]}$$

CT TIME INVARIANT & VARIANT SYSTEM

- **Time Invariant (Shift Invariant):** A system is said to time invariant if the relationship between the input and output does not change with time

$$\textbf{If } y(t) = T[x(t)]$$

$$\textbf{Then } T[x(t-t_1)] = y(t-t_1)$$

- **Time variant (Shift variant):** A system is said to time variant if the relationship between the input and output changes with time

$$\textbf{If } y(t) = T[x(t)]$$

$$\textbf{Then } T[x(t-t_1)] \neq y(t-t_1)$$

CAUSAL & NON CAUSAL SYSTEM

- **Causal System:** A system is said to be causal if the response of a system at any instant of time depends only on the present input, past input and past output but does not depends upon the future input and future output

$$h(t) = 0, \; t<0$$

- **Non Causal System:** A system is said to be Non-causal if the response of a system at any instant of time depends on the future input and also on the present input, past input, past output

$$h(t) \neq 0, \; t<0$$

CT STATIC & DYNAMIC SYSTEM

- **Static System [Memory Less]:** A system is said to be memoryless or static if the response of the system is due to present input alone **Eg.**

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

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

- **Dynamic System [Memory]:** A system is said to be memory or dynamic if the response of the system depends on factors other than present input also **Eg.**

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

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

STABLE & UNSTABLE SYSTEM

- **Stable System:** A system is said to be stable if and only if it satisfies the BIBO stability criterion
- **BIBO stable condition:** Every bounded input yields bounded output. *i.e.*, if $0 < x(t) < \infty$ then $0 < y(t) < \infty$ should be satisfied for the system to be stable
- **Impulse response should be absolutely integrable**

$$\mathbf{0 < \int_{-\infty}^{\infty} |h(\tau)| dt < \infty}$$

- **Unstable System:** If the BIBO stable condition is not satisfied, then the system is said to be unstable system

LINEAR SYSTEM

$y(t) = t\,x(t)$

$$F\underbrace{\left[a_1 x_1(t) + a_2 x_2(t)\right]}_{y_3'(t)} = \underbrace{a_1 y_1(t) + a_2 y_2(t)}_{y_3(t)}$$

$y_1(t) = t\,x_1(t)$

$y_2(t) = t\,x_2(t)$

R.H.S

$$y_3(t) = a_1 t\,x_1(t) + a_2 t\,x_2(t)$$

L.H.S

$$y_3'(t) = t\left[a_1 x_1(t) + a_2 x_2(t)\right]$$

$$= a_1 t\,x_1(t) + a_2 t\,x_2(t)$$

$y_3'(t) = y_3(t)$ Linear system.

NON LINEAR SYSTEM

$y(t) = \sin x(t)$

$y_1(t) = \sin x_1(t)$

$y_2(t) = \sin x_2(t)$

$$\underbrace{F\left[a_1 x_1(t) + a_2 x_2(t)\right]}_{y_3'(t)} = \underbrace{a_1 y_1(t) + a_2 y_2(t)}_{y_3(t)}$$

R.H.S

$$y_3(t) = a_1 \sin x_1(t) + a_2 \sin x_2(t)$$

L.H.S

$$y_3'(t) = \sin\left[a_1 x_1(t) + a_2 x_2(t)\right]$$

$$= \sin a_1 x_1(t) \cos a_2 x_2(t) + \cos a_1 x_1(t) + \sin a_2 x_2(t)$$

$\therefore y_3'(t) \neq y_3(t)$ Non linear system

TIME INVARIANT & VARIANT SYSTEM

1. $y(t) = x(-t)$

$y(t, t_1) = x(-t - t_1)$

$y(t - t_1) = x(-t + t_1)$

$y(t, t_1) \neq y(t - t_1)$ → Time Variant System

2. $y(t) = 10x(t) + 5$

$y(t, t_1) = 10x(t - t_1) + 5$

$y(t - t_1) = 10x(t - t_1) + 5$

$y(t, t_1) = y(t - t_1)$ → Time Invariant System

CAUSAL & NON CAUSAL SYSTEM

$y(t) = 10x(t) + 5$

$y(-1) = 10x(-1) + 5$

$y(0) = 10x(0) + 5$

$y(1) = 10x(1) + 5$

o/p depends upon present input

causal system

$y(t) = x(t+10) + x^2(t)$

$y(-1) = x(9) + x^2(-1)$

$y(0) = x(10) + x^2(0)$

$y(1) = x(11) + x^2(1)$

o/p depends upon future i/p

Non causal system

STATIC & DYNAMIC SYSTEM

$y(t) = x(t)\cos(100\pi t)$

$y(-1) = x(-1)\cos(100\pi t)$

$y(0) = x(0)\cos(100\pi t)$

$y(1) = x(1)\cos(100\pi t)$

o/p depends upon present i/p

Static system

$y(t) = x(t^2)$.

$y(-1) = x(1)$

$y(0) = x(0)$

$y(1) = x(1)$

o/p depends upon future i/p

Dynamic system

ASSESSMENT

1. A system is said to be linear if its obeys ----------
2. Define system and list the classification of system.
3. Relationship between the input and output does not change with time is called ----------
4. Static system is also called as ----------
5. If the response of a system depends on the future input and also on the present input, past input, past output is called ---------- system.
6. If the response of the system depends on factors other than present input also is called ---- -------- system.

THANK YOU