SIGNALS and SYSTEMS

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LECTURE 04

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TOPICS

.Basically, systems are classified into 7 different types

- Classification is based on the input and output characteristics of the systems

1- Lineer and non-linear systems
2- Time variant – time invariant systems
3-Static and dynamic System
4-Causal and non-causal system
5-Invertible and non-invertible system
6-Stable and unstable system
7-Linear time-Variant (LTV) – Linear time invariant (LTI) systems

4.1. Lineer and Non Lineer Systems

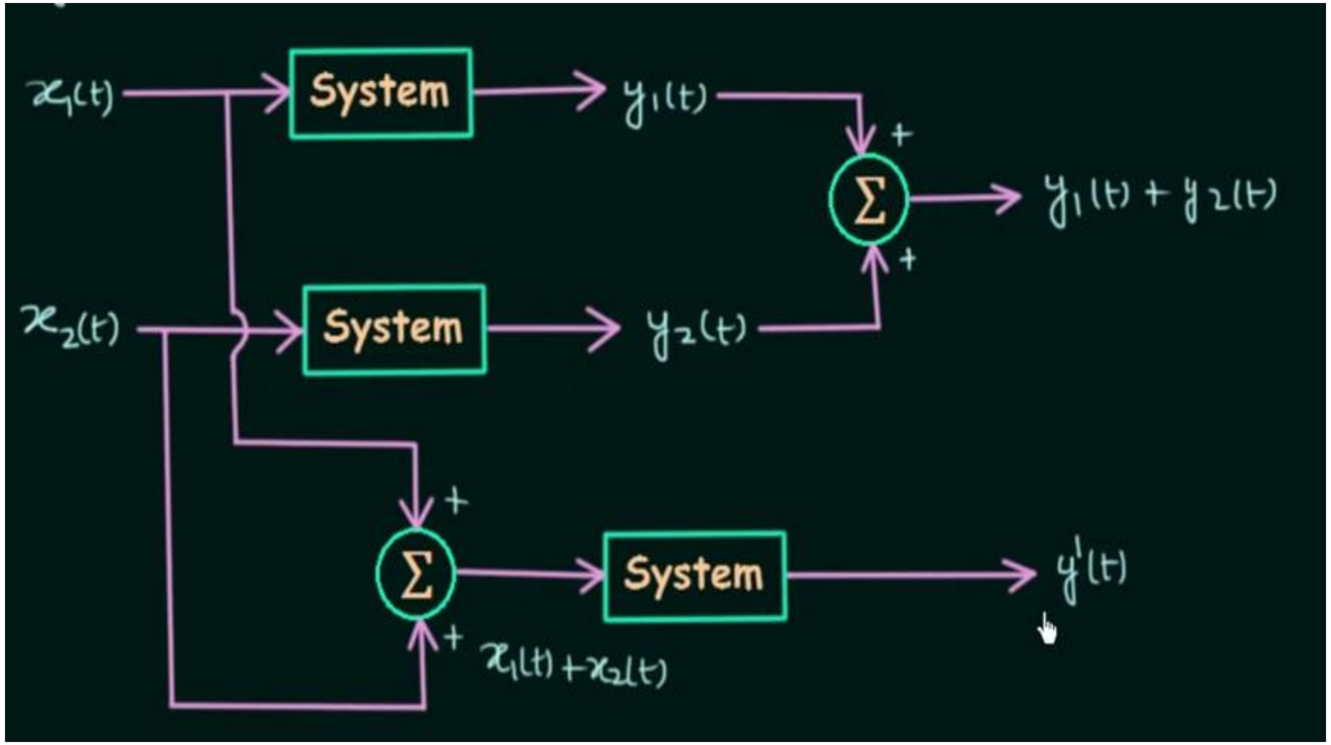
- A system is said to be linear if it satisfies the superposition principle otherwise, the system is said to be non-lineer.

- Consider a system with input x1(t), x2(t) and output y1(t), y2(t). For linearity
  - **$T[a_1x_1(t)+a_2x_2(t)] = a_1T[x_1(t)] + a_2T[x_2(t)]$**

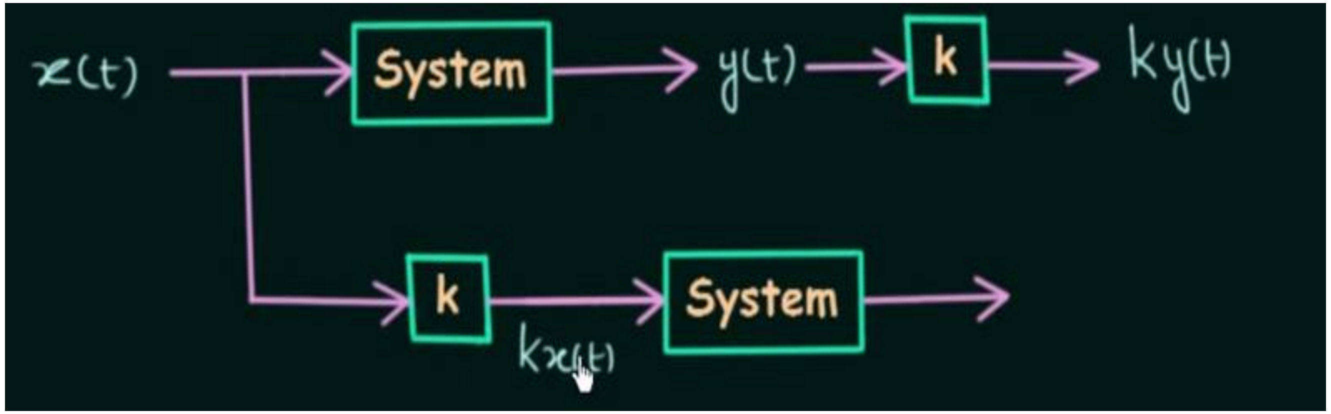
- Superposition Theorem: Combination of Law of Additivity and Law of Homogeneity.

- NOTE: System linearity is independent of time scaling.

4.1. Lineer and Non Lineer Systems



If y’(t) = y1(t)+ y2(t) Then our system is following the LAW OF ADDITIVITY.



If y’(t) = y1(t)+ y2(t) Then our system is following the LAW OF HOMOGENEITY

4.1. Lineer and Non Lineer Systems

- Eg 1: $y(t) = x(t^2)$
- Eg 2: $y(t) = x^2(t)$

4.2. Time Variant and Time Invariant systems

- A system is said to be TIME VARIANT, if its input and output characteristic changes with time.
- Otherwise it is said to be TIME INVARIANT
- If you delay input n time interval (for discrete time signals) or n seconds, then the output must be delayed in the same manner.

- The condition for time invariance is
  - y(n,k) = y(n-k) where
  - y(n,k) = T[x(n-k)]

4.2. Time Variant and Time Invariant systems

- Eg 1: $y(n) = x(n)+x(n-2)$
- Eg 2: $y(n) = ax(n-3)+nx(n-2)$

4.3. Static and Dynamic System

- Static system is memoryless and dynamic system has memory.

- Static System: Output of the system depends only on present values of the input signal.

- Dynamic System: Output of system depends on past or future values of the input signal

AT ANY INSTANT OF TIME

4.3. Static and Dynamic System

- Ex 1: $y(n) = x(n)$ //For solution we will substitute some values for n

- Ex 2: $y(t) = 2\, x^2(t)$

- Ex 3: $y(n) = x(n) + x(n-1)$

- Ex 4: $y(t) = x(t) + x(t+3)$

4.4. Causal And Non Causal Systems

- A system is said to be CAUSAL if its response is dependent upon present and past inputs and does not depend on future output
  - All practical systems in real world are causal systems

- For a NON-CAUSAL system, the output of depends upon future input also.

4.4. Causal And Non Causal Systems

- Ex 1: $y(n) = x(n) + (1 / x(n-1))$

- Ex 2: $y(t) = 2x(t) + (1/ x^2(t))$

- Ex 3: $y(n) = x(n) + 2x(n+1)$

- Ex 4: $y(t) = x(t) + x(t-3) + x(t+1)$ //Hint: Anywhere future response includes means a causal sytem.

4.4. Causal And Non Causal Systems

- All NON-CAUSAL systems are DYNAMIC in nature but,
  All DYNAMIC systems are NOT NON-CAUSAL.

- All STATIC systems are CAUSAL but,
All CAUSAL systems may not be STATIC

Static And Dynamic Systems

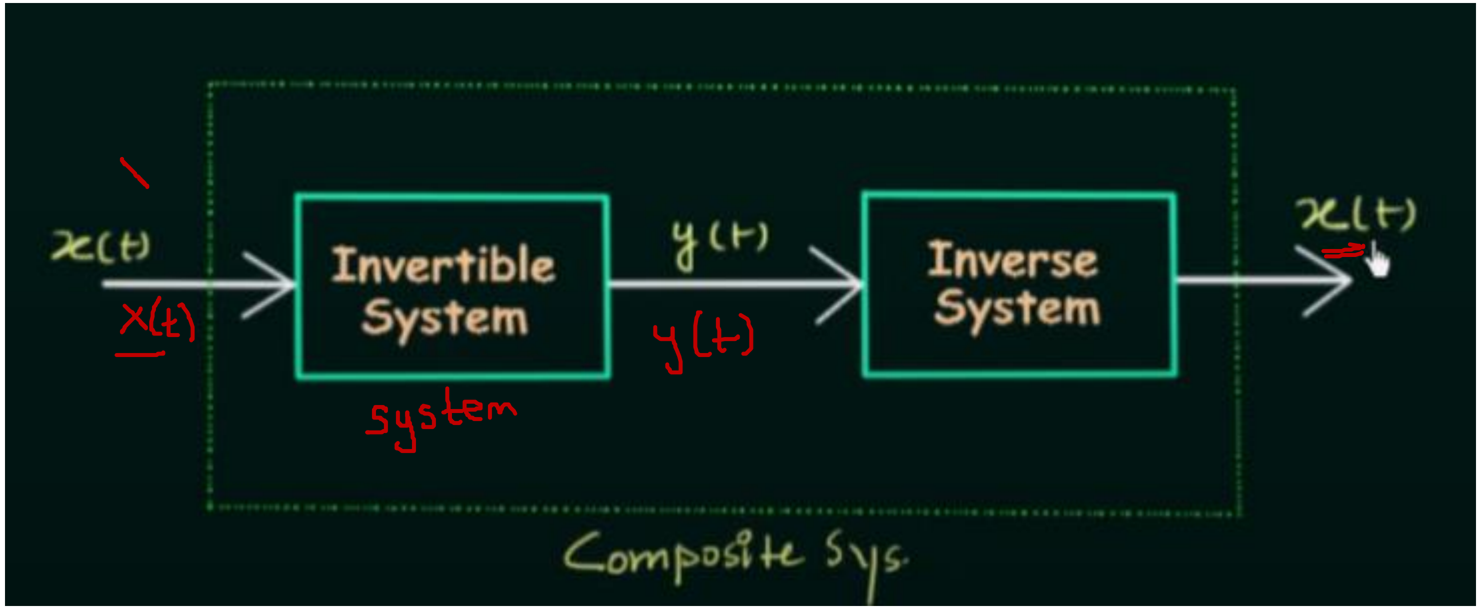
STATIC	DYNAMIC
The response depends only on PRESENT inputs	Includes responses depend on past and/or future inputs

Causal And Non Causal

CAUSAL	NON – CAUSAL
The system response is INDEPENDENT from FUTURE values of INPUT . Past values of Inpıt signal is possible.	System response depends future values of the INPUT. There may be present and past values but FUTURE dependency must take place.

4.4. Invertible and Non Invertible Systems

- ❑ A system is said to be invertible if the input of the system appears at the output.



- ❑ For an invertible system, there should be one to one mapping between input and outout at each and every instant of time.

4.4. Invertible and Non-Invertible Systems

- Ex 1: $y(t)= x^2(t)$ // Non-invertible. Why?
- Ex 2: $y(t) = x(t) + 2$ // invertible why?
- Ex 3: $y(t) = |x(t)|$
- Ex 4 : $y(t) = y(t)= \sin t. x(t)$

4.5. Stable an Unstable System

- A system is said to be stable when it produces a bounded output to a bounded input at each and every instant of time.

- Bounded input / Bounded output criteria: This is known as BIBO criteria.

- With the term bounded, we mean that from at each and every instant of time, the amplitude of the signal must be finite.

- Eg: sint, cost, u(t) stable

4.5. Stable an Unstable System

- Ex 1: $y(t) = t. X(t)$
- Ex 2. $y(t) = x(t) +2$

- Next week, we will discuss
    - Lineer Time Invariant Systems
    - Convolution

Thank You