SIGNALS & SYSTEMS

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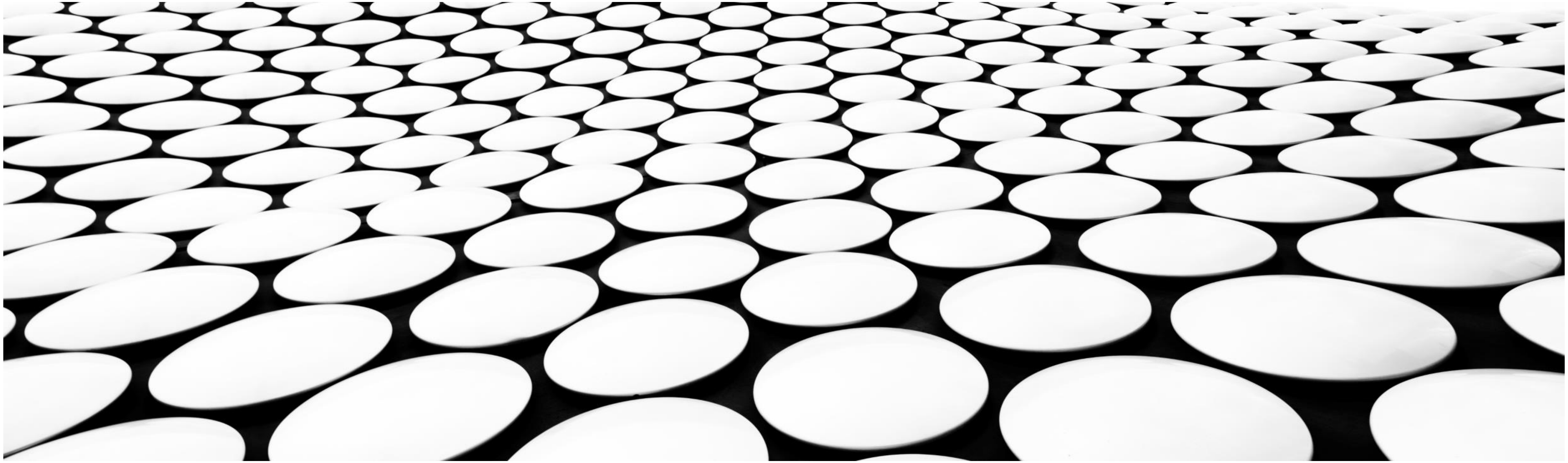


Causal system → The o/p value of the system → present / past } value of i/p

Doesn't depend on Future value

Non - causal → past, present but importantly on future value

Anti - causal → strictly depends on future value.

past value ✗

present value ✗

All real - life systems / practically realizable } → causal.

$$y(t) = \begin{cases} x(3t) & ; \ t < 0 \\ x(t-1) & ; \ t \geq 0 \end{cases}$$

Solⁿ:-

when, $t = -1$ $\quad y(-1) = x(3(-1)) = x(-3) \rightarrow$ causal

$t = 0$ $\quad y(0) = x(0-1) = x(-1) \rightarrow$ causal

$t = 1$ $\quad y(1) = x(1-1) = x(0) \rightarrow$ causal.

$$y(t) = \underbrace{\sin(t+1)}_{\text{coefficient}}\, x(t-1)$$

trigonometric fn is always constant.

$\sin(t) \rightarrow \underline{-1 \le \sin t \le 1}$

i/p

$x(t) \rightarrow$ System $\rightarrow y(t)$

$$\left.\begin{aligned} y(-1) &= x(-2) \\ y(0) &= x(-1) \\ y(1) &= x(0) \end{aligned}\right\} \text{past values of i/p} \Rightarrow \text{causal system.}$$

$y(t) = x(e^t)$ → causal or non-causal ?

$t=0 \Rightarrow y(t) = x(e^0) = x(1)$ → future value of i/p ⇒ Non-causal.

$$y(t) = \int_{-\infty}^{t} x(\tau)\, d\tau$$

⇓

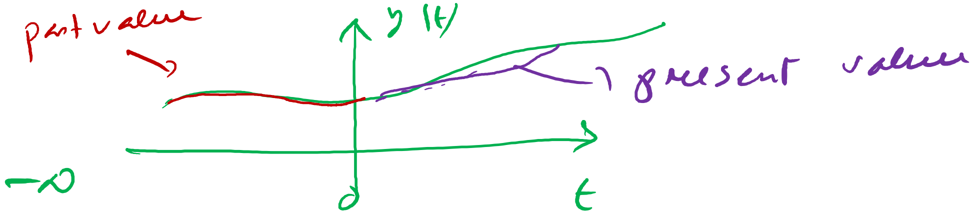
Area under curve

Causal system

Static and dynamic
↓ without memory
↓ with memory

∫ integral and differential ⇒ dynamic

past value → $-\infty$ to 0



$$y(t) = \int_{-\infty}^{t+1} \underline{x(\tau)}\, d\tau$$

look for the limit → upper limit associated with integral.

Let us consider $\tau = t+1 \Rightarrow x(t+1)$

$$y(t) = x(t+1)$$

$t=0 \Rightarrow y(0) = x(1)$ → Future value → Non-causal.

$t=-\infty \Rightarrow y(-\infty) = x(-\infty+1)$ → causal value

Non-causal <u>system</u>.

$$y(t) = \int_{-\infty}^{t-1} x(\tau)\, d\tau$$

$$y(t) = \int_{-\infty}^{t} x(3\tau)\, d\tau$$

$\tau = t-1$

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

$\Rightarrow y(0) = x(-1)$

$y(-1) = x(-2)$

$y(1) = x(0)$

causal system because o/p y(t) depends on past value of i/p

$\tau = t$

$y(t) = x(3t)$

$t = -1 \Rightarrow y(-1) = x(-3)$

$t = 0 \Rightarrow y(0) = x(0)$

$t = 1 \Rightarrow y(1) = x(3)$

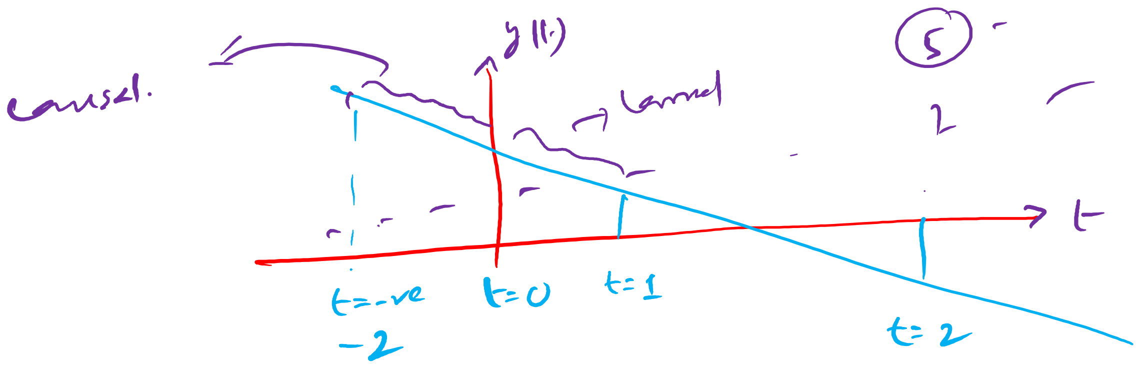
Non-causal system.

Future value of the i/p

SERVICE BEFORE SELF

$$y(t) = \frac{dx(t)}{dt}$$

This is nothing but the slope of any st. line → Equation.



Causal system

Time variant and Time invariant system:-

A system is said to be time invariant if it's o/p - i/p characteristics doesn't change with time.

Advanced

Delayed

Time shifting → You shift i/p by some amount / value

⇓

O/p is not changing w.r.t change in i/p

⇓

Time-invariant system

change in i/p ⇒ change in the o/p

⇓

Time variant system.

step no: 1 :-

$$x(t) \longrightarrow \overset{H(t)}{\boxed{\text{system}}} \longrightarrow y(t)$$

provide delay to the o/p

$$x(t) \longrightarrow \boxed{H(t)} \longrightarrow y(t) \longrightarrow \boxed{\text{delayed by } t_0} \longrightarrow y(t-t_0) \quad \text{——} \quad (1)$$

step no: 2 :-

provide delay to the i/p.

$$x(t) \longrightarrow \boxed{\text{delayed by } t_0} \longrightarrow x(t-t_0) \longrightarrow \overset{H(t)}{\boxed{\text{system}}} \longrightarrow y'(t) \quad \text{——} \quad (2)$$

if $y'(t) = y(t-t_0) \Rightarrow$ Time-invariant system

or, $y'(t) \neq y(t-t_0) \Rightarrow$ Time-variant system.

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

change everything for i/p

Sol^n:-

$y(t) \rightarrow$ delayed by $t_0 \rightarrow y(t-t_0) = x[2(t-t_0)] = x(2t-2t_0)$

$x(t) \rightarrow$ delayed by $t_0 \rightarrow x(t-t_0) = x(2t-t_0) = y'(t)$

look for any dependent variable.

$y'(t) \neq y(t-t_0) \Rightarrow$ Time variant.

$x(2t) \rightarrow$ Time scaling $\rightarrow$ it is always performed for the independent variable $\rightarrow$ i.e. t

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

$y(t) \longrightarrow$ delayed by $t_0 \rightarrow y(t-t_0) = 2 + x(t-t_0)$

$x(t) \longrightarrow$ delayed by $t_0 \rightarrow x(t-t_0) = 2 + x(t-t_0) = y'(t)$

$y'(t) = y(t-t_0) \Rightarrow$ The system is time-invariant.

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

$y(t) \rightarrow$ delayed by $t_0 \rightarrow y(t-t_0) = x[\cos(t-t_0)]$

$x(t) \rightarrow$ delayed by $t_0 \rightarrow x(t-t_0) = x[\underline{\cos t} - t_0] = y'(t)$

whenever o/p is delayed by $t_0 \rightarrow$ make changes to all t in i/p.

whenever i/p is delayed by $t_0 \rightarrow$ only look for dependent variable.

$$y(t^3) = x(t)$$

$$y(t) \xrightarrow{\text{delayed by } t_0} y(t-t_0) = y((t-t_0)^3)$$

$$x(t) \xrightarrow{\text{delayed by } t_0} x(t-t_0) = y(t^3 - t_0)$$

Time variant system